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COVER: The turkey shares pride of place with the broiler as the cheapest source of meat available today in many parts of the world (photo courtesy of Government of Israel).

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VAMPIRE BATS

and their effect on cattle production in Latin America

The common vampire bat (Desmodus rotundus)

The interaction between vampire bats and man predates the arrival of Europeans in the new world. The Mayas and Aztecs considered vampire bats important enough to rank them as deities. Villa (1969) attributed this importance to the vampire's role in disease transmission — probably rabies. He pointed out that the Spanish conquistadors lost numerous cavalry horses to bat-transmitted rabies, and early missionaries suffered heavy livestock losses. The vampire bat continues to this day to be an economic pest and a rabies vector in tropical America.

This article summarizes some of the interesting and unique natural history of the vampire bat, its importance as a rabies transmitter and economic pest, and past methods used to control it, as an introduction to a report on the recent efforts of the Denver Wildlife Research Centre (Colorado, United States) at vampire control.

by Nelson B. Kverno and G. Clay Mitchell

Strictly speaking, the term "vampire" actually refers to three haematophagous (blood-eating) bat species in the family Phyllostomatidae. However, only one, the common vampire *Desmodus rotundus*, is economically damaging to man. This species has less specialized feeding habits than the other two and has exploited the opportunities made available by man's introduction and husbandry of livestock. The common vampire is the species referred to throughout this article.

The common vampire extends from tropical Mexico to northern Argentina. Its current range and distribution within this boundary depend on food supply, acceptable roost sites and climatic tolerance (McNab, 1973). Its density within the range, however, appears to be simply a function of food supply (Villa, 1969). Man has, in general, increased both the distribution and density of the vampire within its range. He has allowed it to spread by creating new roost sites — for example, mines, wells and aqueducts. More important, he has increased both its spread and its density by making available more food in the form of livestock (Dalquist, 1955).

The vampire bat is colonial, although its colonies are small (50-200 members). Throughout most of its range, it roosts in such shelters as caves, hollow trees and mine shafts. Vampire colonies are always clearly segregated from other bat species in the

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Fresh vampire bat bite on a horse

same roost, but vampires within the colony are quite gregarious. They roost close together and spend considerable time in contact with each other.

Vampires have low fecundity, presumably giving birth to only one young a year (Wimsatt and Trapido, 1952), but are long living. Linhart (1973) found that the age of wild-trapped vampires averaged 2.6 years and ranged up to 13 and 14 years. Also, their nocturnal habits and secluded roosts protect them from predation. Thus, the vampire's low natality is compensated by its longevity and by low predation. The contribution of the cattle industry as an additional food source has resulted in an imbalance where natality exceeds mortality, and so the population has expanded. Neither man nor nature has effectively reversed this trend.

The vampire feeds exclusively on blood. Its teeth are designed for cutting through the skin; the lower incisors are separated to permit the tongue to lap the blood escaping from the wound (Pawan, 1936). It is this unique feeding specialization that accounts for the vampire's notoriety as an economic pest and rabies vector. It is also this feature that has facilitated the development of an ecologically sound means of managing the species.

Calf with multiple vampire bat bites on face, ears and neck

Economic significance

Vampires were clinically shown to carry rabies in 1911 (Pawan, 1936). Bat-borne rabies is the paralytic type, which is highly virulent to most animals, but vampires possess a degree of tolerance or reservoir ability (Pawan, 1936). In fact, an infected bat, capable of transmitting rabies, may appear healthy and not even exhibit symptoms of the disease (unpublished data, Denver Wildlife Research Centre). The virus, found in the saliva, is conveyed to other members of the colony primarily through biting (Villa, 1969). Unlike insectivorous or fruit-eating bats, the vampire is an ideal vector to host species because it inflicts a wound when feeding.

The most obvious loss attributable to the vampire is the direct loss of its livestock host to rabies. The economics of bat-transmitted rabies in cattle has not been well documented. The accuracy of reporting varies appreciably among countries, as do diagnostic procedures. However, since verification of the disease requires laboratory examination of fresh brain tissue, most deaths are diagnosed only when there are clear external signs. Even so, the estimates of bovine mortality to bat-transmitted rabies in Latin America are staggering: Acha (1967) estimated annual losses of half a million head

of cattle; Malaga-Alba (1959) estimated 1 million head; and Constantine (1970) quoted Steele's estimate of 2 million head, which he translated as a direct loss of $100 million a year. Mortality estimates are unavailable for livestock other than cattle.

Estimates of secondary losses are even more vague. Constantine (1970), again quoting Steele, reported that indirect losses approach $250 million a year. This figure is not as excessive as it may first appear, since the number of cattle bitten daily adds up to millions and the resulting blood loss amounts to several thousands of litres. The average adult vampire bat weighs 30 g and consumes approximately its weight in blood daily. With an estimated additional 20 ml of blood lost through bleeding of the wound, each bite represents a loss of about 50 ml of blood. Recently, in Nicaragua, an average of 400 fresh bites a day on a herd of 100 cattle was recorded. At 50 ml per bite, the blood loss in this herd was about 20 litres a day. The effect of bloodletting on weight gain in beef cattle and on milk production in dairy cattle has not been determined, but it will probably prove to be a major protein loss. Secondary infections and reduced hide quality due to bite wounds add further to this list of losses.

Aggregate economic losses are important statistics, for they reflect the impact on a nation's gross national product. But only when the losses are expressed in terms that the individual can relate to, is there a real appreciation of the problem and an understanding of the human anguish involved. An example is provided by the impact on the owner, his family and the employees of a moderately large ranch in Bolivia, from the following losses in 1972 to vampire bat-transmitted rabies: 200 of their 1 400 cattle, 9 of their 70 horses, 18 of their 20 pigs, and 25 of their 70 goats. Even more traumatic were the losses sustained by a smaller rancher in Nicaragua: in 1 month (January 1974), 50 of his 60 cattle died of rabies.

Vampire bats captured in a mist net

Deaths of single animals are often regarded as unimportant, but when one considers the innumerable cases where rural families have lost their only milk cow — often their most valuable possession — they assume real significance.

Numerous attempts to reduce vampire populations have been employed over the years. Destruction of roosts with explosives and fumigation of caves are two procedures that have proved partly effective, but their application is limited to known roosts. Moreover, these methods are not selective and have resulted in the death of large numbers of beneficial bats (Villa, 1969). Their use is therefore strongly discouraged. Poisoning vampires by applying a strychnine-syrup mixture to bite wounds on cattle has also been suggested (Greenhall, 1963). Since this method relies on the bats rebiting the old wounds, and can only be used with docile cattle, it is moderately effective at best. Greenhall (1963) also reported some success in capturing bats with mist nets placed around tethered cattle.

Other methods of control that have been attempted include electrocution (Villa, 1969), traps (Constantine, 1958) and shooting (Greenhall, 1970). None of these procedures have been really effective in solving the vampire problem.

Vaccinating against rabies is effective in combating the disease in cattle. Vaccines are available that will provide protection for as long as four years. In most Latin American countries reliable vaccines must be imported, and cost as much as US$2.50 per dose. Also, for satisfactory results the vaccines require special care in handling and applying, which they have not always received. Because of the high cost and a history of frequent failure, most ranchers do not vaccinate until they experience a rabies outbreak. Thus, as Constantine (1970) concluded, even though effective rabies vaccines are available, better protection can probably be achieved by controlling the vampire bats. It might also be noted in this connection that vaccination cannot be a total alternative to bat control,

Left: *Removing a vampire bat from a mist net*

Right: *Vampire bats roost in caves in tightly packed groups. This close body contact helps to pass the topically applied control compound from one carrier to many others.*

Below: *Treating a vampire bat with diphenadione paste prior to its release*

although modern vaccines provide a high degree of protection against bat-transmitted rabies. If bat predation remains frequent, economic losses will continue to be important even with vaccinated animals, due to blood loss and wound contamination.

Some recent efforts

Under the authority of the Foreign Assistance Act, the United States Agency for International Development (AID) requested assistance in 1967 from the U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, to conduct research on the vampire bat problem in Latin America. In June 1968 a programme was initiated through the Bureau's Wildlife Research Centre in Denver, Colorado, under the auspices of AID. The objective was to develop safe and selective methods for reducing damage to cattle by vampire bats in Latin America. The programme consisted of two elements: a laboratory team at the Denver Centre and a field team in Palo Alto, Mexico. Mexico's Secretaría de Agricultura y Ganadería, Instituto Nacional de Investigaciones Pecuarias, cooperated in the field project.[1]

This programme was the first major research effort directed toward the development of management procedures for vampire bats. The first two years were devoted mainly to exploratory studies. Laboratory investigations concentrated on the species' unique physiology and its toxicological tolerances to some potential control chemicals. Field investigations were more concerned with the species' general biology and behaviour.

Research findings

During these initial studies it became apparent that the only practical locations where the bats could be attacked were the two places where they congregated — the roost and the feeding site. It was also determined that roosting vampires spend nearly 10 percent of their time grooming themselves and each other (Flores Crespo *et al.*, 1972). Toxicology studies showed that vampires were highly sensitive to anticoagulants — drugs that interfere with blood clotting (Thompson *et al.*, 1972).
The difference between success or failure in achieving research objectives often depends upon the ability of the investigators to assimilate and utilize bits of seemingly unrelated information. Such was the case with S.B. Linhart, who conceived the idea of placing an anticoagulant, in some sticky substance, on the backs of captured bats and releasing them to carry the chemical back to the roost and contaminate other members of the colony. Although vampires feed exclusively on blood, he concluded that the colony members would ingest toxic levels through mutual grooming. To test this idea, he removed a single vampire bat from a 20-bat laboratory colony, treated it with 1.5 ml of petroleum jelly containing 50 mg of an anticoagulant drug, and then returned it to the colony. The treated bat was dead the following morning, and 18 of the remaining 19 bats died within 14 days (Linhart *et al.*, 1972).
Encouraged by the laboratory results, the team tested this procedure under field conditions in Mexico. On two ranches cattle were corralled and

[1] This cooperative research was conducted with funds provided to the Bureau of Sport Fisheries and Wildlife by the United States Agency for International Development, under the project entitled The Control of Vertebrate Pests, USDI/PASA RA(ID) 1-67.

mist nets were placed around the corrals. All vampire bats captured during the night were treated topically with petroleum jelly containing an anticoagulant and then released. When the ranches were revisited two weeks later, the number of fresh vampire bites on the cattle had been reduced by 94 and 97 percent respectively, and 95 and 97 percent fewer vampires were netted that night.

Several tests were also conducted on vampire colonies in caves, to confirm the effectiveness of treating only a few colony members and also to determine the effect on beneficial bats using the same roost. Actual counts of vampires in these caves showed that as many as 22 untreated colony members could be killed for every vampire treated. Of several other bat species in the caves, none were found dead (Linhart *et al.*, 1972).

After these initial field trials, laboratory studies were conducted to select the best anticoagulant and establish the minimum effective levels required. The final recommendation for topical treatment of each vampire was 25 mg of diphenadione.

About the same time that the topical treatment was being developed, other investigators, under the direction of R.D. Thompson at Denver, were evaluating systemic treatments of livestock with anticoagulants. This method capitalizes on the daily requirement of vampire bats for blood and the different sensitivity of cattle and bats to anticoagulants. These studies showed that the LD_{50} (dose lethal to 50 percent of the population) of a single oral dose of diphenadione to vampires was 0.91 mg/kg of body weight, but that a single oral dose of 5 mg/kg in cattle produced only a moderate, temporary increase in the clotting time of plasma prothrombin. The tendency for the anticoagulant to bind to the blood protein of cattle for several days, the sensitivity of vampire bats to the drug, and the concentrating effect in the bats due to the relatively large amounts of blood they consume in relation to their own blood supply, proved to be a lethal combination.

When cattle were injected in the rumen with 1 mg/kg of diphenadione, single feedings of the cattle blood, at 24, 48 and 72 hours after injection, killed all the vampires in the test. Field studies in Mexico confirmed the effectiveness of this systemic approach. Cattle at three ranches were

corralled and injected with 1 mg/kg diphenadione. After two weeks fresh vampire bites had been reduced 93 percent (Thompson *et al.*, 1972).

When livestock are treated systemically, chemical residues in the animals' meat and milk must be low enough for safe consumption. The workers at Denver therefore conducted preliminary tests to ensure that vampire control treatments with diphenadione would not produce toxic residues. Laboratory rats fed nothing but liver from treated cattle showed no effects (Thompson *et al.*, 1972). Likewise, calves showed no effects and no change in prothrombin clotting time when they fed exclusively on milk from cows treated at 2.75 mg/kg, nearly three times the recommended dose. More recently, sensitive procedures have been developed to analyse diphenadione residues chemically; these confirm that only traces of the drug are present in milk or body tissues of treated cattle (R.W. Bullard and R.D. Thompson, unpublished). Since diphenadione is a standard anticoagulant used in human therapy, with daily doses ranging between 2.5 and 30 mg (Martin, 1970), the systemic treatment appears to be quite safe.

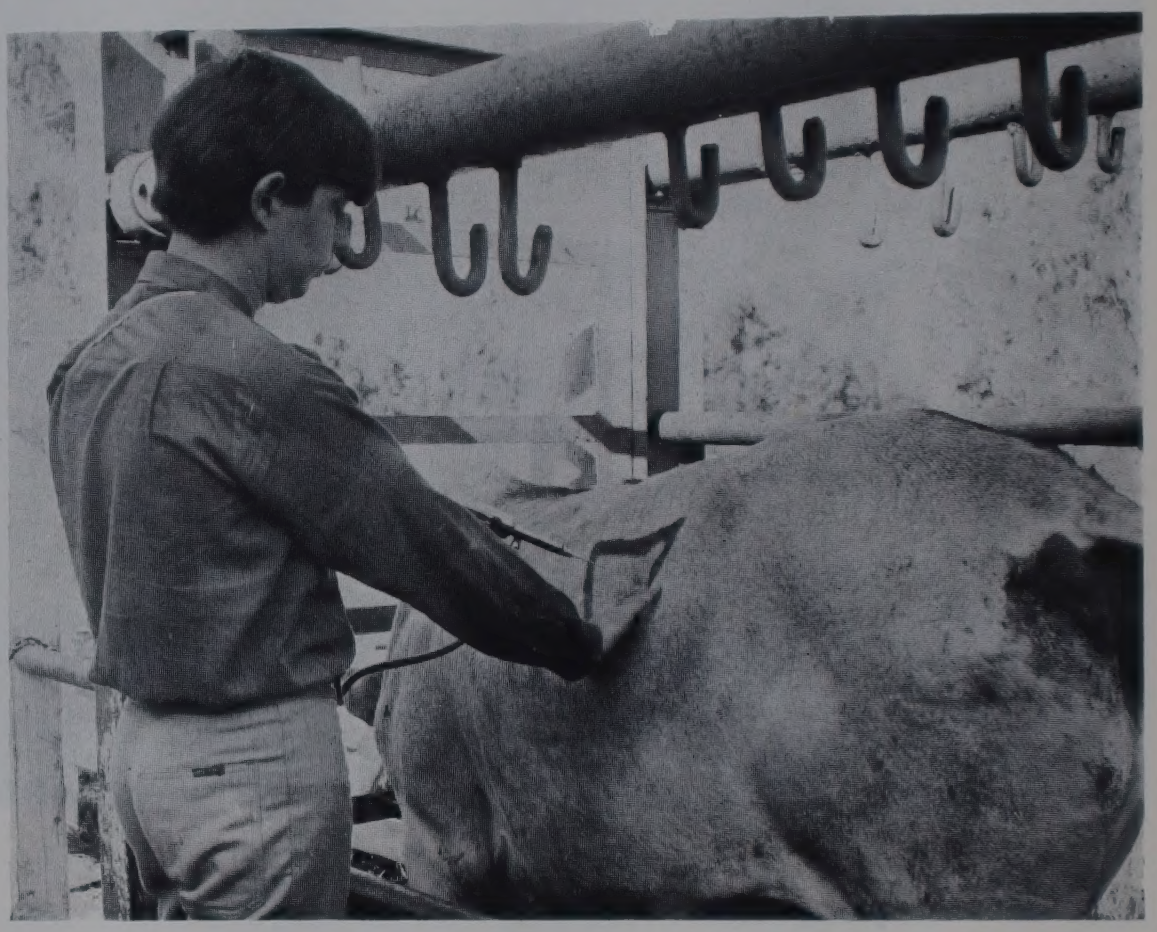
Field test results

With the excellent results from the preliminary trials, the research team began the process of field testing the topical and systemic methods and demonstrating their use to nationals in countries throughout Latin America. The results continued to be excellent. Initial reductions were almost always 90 percent or better, and vampire populations generally remained low for long periods after treatment.

How often control will have to be repeated depends, of course, on how quickly vampire bat populations recover in the area. Although vampires have a low reproductive potential, the gap may be filled by new bats moving in from surrounding areas. Homogeneous, favourable habitats, where there has been little control and where vampire populations are relatively high and uniform, will undoubtedly repopulate more rapidly than areas where vampires occur only in isolated pockets. It has generally been found that the more arid the region, the better are the chances that populations will be small and scattered, and therefore that control will be effective for long periods. But this can also happen in humid regions.

An example of this is provided by three field demonstrations of the topical method conducted in January 1972 at ranches in northeastern Brazil, in the state of Pernambuco. Two were in the humid coastal region near Cabo and the third in the arid region to the east near Aguas Belas. These ranches were revisited one year after treatment; those near Cabo were also reevaluated after 18 months. The results of these investigations are summarized in the table.

The isolated vampire bat colony at the ranch near Aguas Belas was practically eliminated; repeat control will probably not be required there for many years. The colonies at the two ranches near Cabo will probably also be slow to recover. Although the coastal climate near Cabo is more favourable for vampires, the region is extensively devoted to sugarcane growing and probably supports a low overall vampire bat population. The isolated cattle herds at the two test ranches doubtless provided the opportunity for equally isolated vampire colonies to become established and survive. Thus, fresh bites were still down 92 and 80 percent respectively 27 months after treatment.



Injecting diphenadione into rumen compartment of a cow's stomach. Note injection should be made in the area of the triangle drawn on the cow.

Safety and selectivity

The welfare of nontarget species should always be of paramount importance in the development of any control procedures. In past programmes, selectivity has often become secondary to the control of vampire bats. The two methods developed in our programme are both quite safe for nontarget species of bats. In fact, the selective removal of vampires could actually benefit other bat species in some areas by reducing competition for roosting space.

The topical method gets high marks

Results of topical application of diphenadione to vampire bats at three cattle ranches in two areas of Brazil

Ranch	Habitat	Time checked, in relation to treatment	No. of cattle checked	No. of fresh bites	No. of vampires treated	Reduction in bites after control - %
Engenho Santo Estavao, near Cabo	Coastal, humid	Before	44	73	33	
		14 days after	44	0		100.0
		1 year after	45	4		94.5
		18 months after	45	4		94.5
		27 months after	42	14		80.8
Engenho Velho, near Cabo	Coastal, humid	Before	60	67	54	
		14 days after	60	3		95.5
		1 year after	60	6		91.0
		18 months after	60	6		91.0
		27 months after	67	5		92.5
Fazenda Barra Nova, near Aguas Belas	Inland, arid	Before	195	74	80	
		11 days after	195	0		100.0
		1 year after	260	0		100.0

for selectivity, since vampires are gregarious only with other vampires. However, this method does require special training to ensure its proper application. Since the nets may catch other species of bat, it is essential that the operators receive instruction in how to identify and handle vampires (Greenhall, 1972), and that they develop sincere concern for the welfare of beneficial bats. Inherent in the method is the possibility that predators will locate and consume an occasional treated bat that has fallen from the roost. Control programmes will be too infrequent, however, to adversely affect predator populations. For selectivity, the systemic approach appears virtually flawless. This method is not only species specific, but affects only those vampires in the population that feed on treated cattle. This aspect may account for the slightly lower kills than those recorded with the topical method; all bats within a colony do not necessarily feed on the same host animals every night. The systemic procedure has the additional advantage of requiring that only the cattle be handled, and giving them injections is already a common procedure at most ranches. The chemical costs somewhat more than for the topical method but is still inexpensive. Based on current prices, treating cattle costs about $15 per hundred doses, or 15 cents a head.

Conclusions

In the brief period of five years, a team of biologists, starting with only the most basic information, developed a solution to a problem that has plagued man for centuries. During the next two years, as we move from the glow of research success into the realities of application, we will test the limits of the procedures that have been developed. No wildlife problem that covers approximately one eighth of the earth's land surface can be thought of as a single problem. The unique features in each new situation will require a programme of adaptive research to refine the procedures and correct deficiencies.

No species of vertebrate should be considered pests *per se*. Only individuals of the species are involved in pest situations. The objective of control programmes should therefore be to provide relief from the damage, not just to kill animals. Vampire bats are no exception, for they are fascinating and unique creatures. Because they have an extensive range and feed on a variety of vertebrate hosts, there is no need for concern that our control methods will eliminate the species. Nevertheless, control programmes, even those as selective as ours, should be confined to those areas where livestock values or human health are in jeopardy.

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TICK-BORNE LIVESTOCK DISEASES AND THEIR VECTORS

2. Epizootiology of tick-borne diseases

This article is concerned with aspects of the epizootiology of the more important tick-borne diseases of cattle: babesioses, theilerioses, anaplasmoses and cowdriosis. These are considered in the order in which the causal agents were discovered and described. Some of the opinions expressed are not necessarily accepted by all workers, and some statements, especially on parasites of the family Theileriidae, are based on unpublished work.

by Gerrit Uilenberg

A knowledge of the epizootiology of tick-borne diseases is of fundamental importance for their effective control. It is only by understanding how the different pathogens are transmitted, what factors influence transmission, and in what ways the animal defends itself against the clinical effects of infection that one can hope to devise successful methods of disease control. This is especially true in areas where complete eradication of the tick vectors is not feasible due to acaricide resistance, or human problems such as poor dip management, irregular attendance of herds at dips or sprays, etc., or because wild animals serve as reservoirs for tick populations.

Anaplasma and *Cowdria* are not protozoa like *Babesia* and *Theileria*, but belong to the order Rickettsiales. Nevertheless, all these infections share a few common points in their epizootiology. The simplest epizootiological model is provided by bovine babesiosis, caused by *Babesia argentina* and *Babesia bigemina* in Madagascar and Australia where the only vector is the one host tick, *Boophilus microplus*. In practically the whole of Madagascar and in much of the tropical north of Australia the climate is favourable for this tick. Wild animals do not serve as reservoirs for either the tick or the babesial parasites. Cattle, after recovery from their first infection, remain carriers for a considerable period, and the opportunity for a proportion of the tick population to be infected is excellent at all times. Because of favourable climatic conditions, the tick population remains at a high enough level to infest all calves shortly after birth, and as a result all young calves become infected with both species of *Babesia*. However, since young calves up to the age of about nine months are more resistant to the clinical effects of the infections than older animals, and since protective antibodies from the dam are transmitted to the calf via the colostrum, there is no mortality and no apparent signs of disease. Immunity among the adult cattle is maintained and reinforced by frequent reinfection. This situation in which *Babesia* infection is widespread but does not constitute a disease problem is described as enzootic; there is no apparent babesiosis, but all animals are infected and are resistant to clinical illness. The whole of Madagascar can be considered as enzootic for these babesial parasites of cattle, but in Australia the climate becomes less and less favourable for the tick as one goes south toward the drier interior and toward the cooler subtropical coastal regions, where the tick population falls to a level so low that not all calves acquire the *Babesia* infections. Here the proportion of susceptible adults is variable, and these animals will show clinical disease when exposed to infected ticks, often resulting in mortality. This situation may be described as epizootic when the disease is apparent, and may lead to outbreaks.

Where seasonal climatological factors favour a temporary increase in the tick population, or where a herd with many susceptible animals is moved into a region with more ticks, the epizootic situation becomes unstable. However, as one moves farther away from the enzootic areas, the tick population density becomes lower until only sporadic cases of babesiosis are seen; one finally reaches the tick-free area where the vector cannot survive and the whole cattle population is susceptible.

Movement of cattle from free areas into epizootic and enzootic areas, and from epizootic into enzootic areas, will result in disease, as will,

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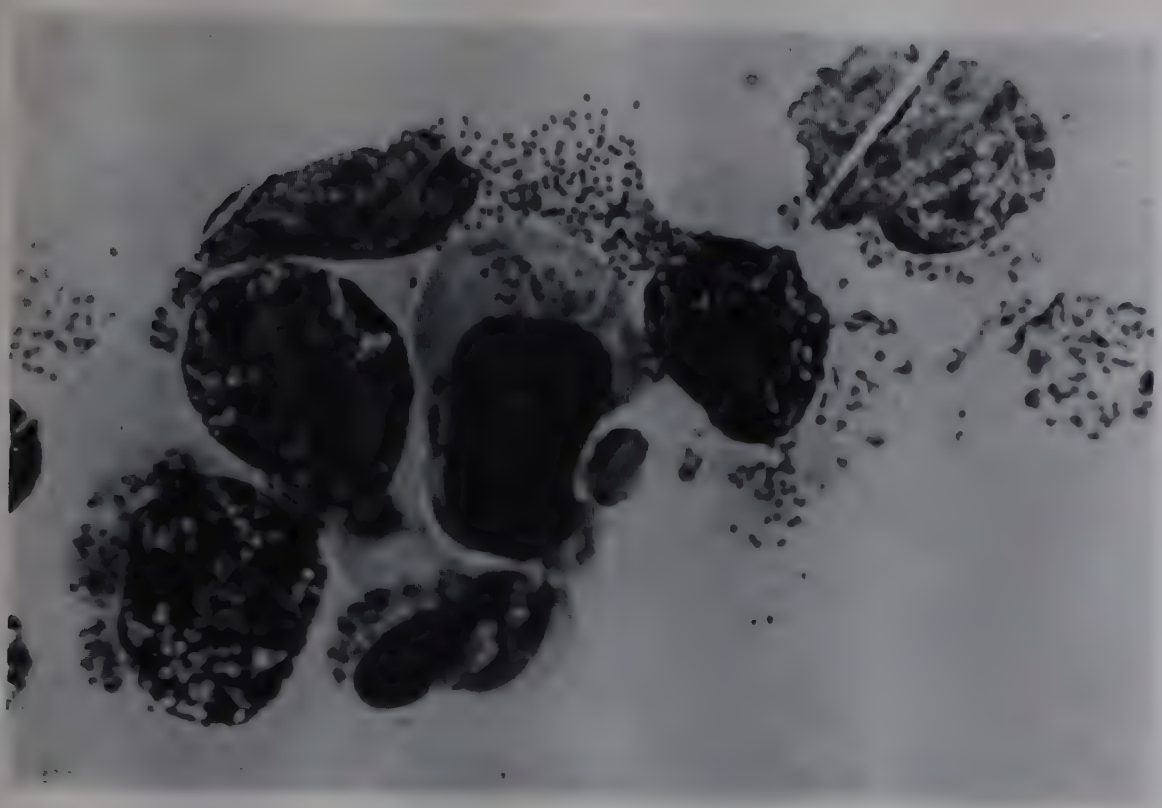


Theileria parva macro- and microschizonts in lymph-node

of course, the importation of susceptible cattle from other countries. Control of ticks changes the picture and may create epizootic or free situations in isolated farms inside an enzootic region, depending upon the efficacy of tick control. Paradoxically, the best method for controlling babesiosis in an enzootic area is not to control ticks! But where humpless cattle (*Bos taurus*) are concerned, it is necessary to limit the numbers of ticks in an enzootic area, since the animals will suffer from tick-worry and loss of blood through the sheer numbers of ticks. This is less important for the zebu breeds (*Bos indicus*), which have the ability to limit tick numbers by immunological means (e.g., Seifert, 1971). Therefore, in enzootic areas tick control may not be necessary on zebu cattle, while control of ticks on humpless cattle may in many instances be limited to reducing the tick population to a level where their numbers have no direct harmful effect, but still remain sufficiently high to ensure infection of all young calves.

Intensive control of ticks with the aim of eradicating them is not usually feasible in enzootic areas, and will only serve to create an epizootic situation or a temporary free pocket in the infested zone, with disease problems becoming apparent where there were none before. But in epizootic areas or in those that have been made epizootic by a partial reduction of tick numbers, control of babesiosis will always be necessary. Such control can be achieved by immunization against *Babesia* or by intensification of tick control measures with a view to eradication. The latter should preferably be applied to a whole region rather than to single herds.

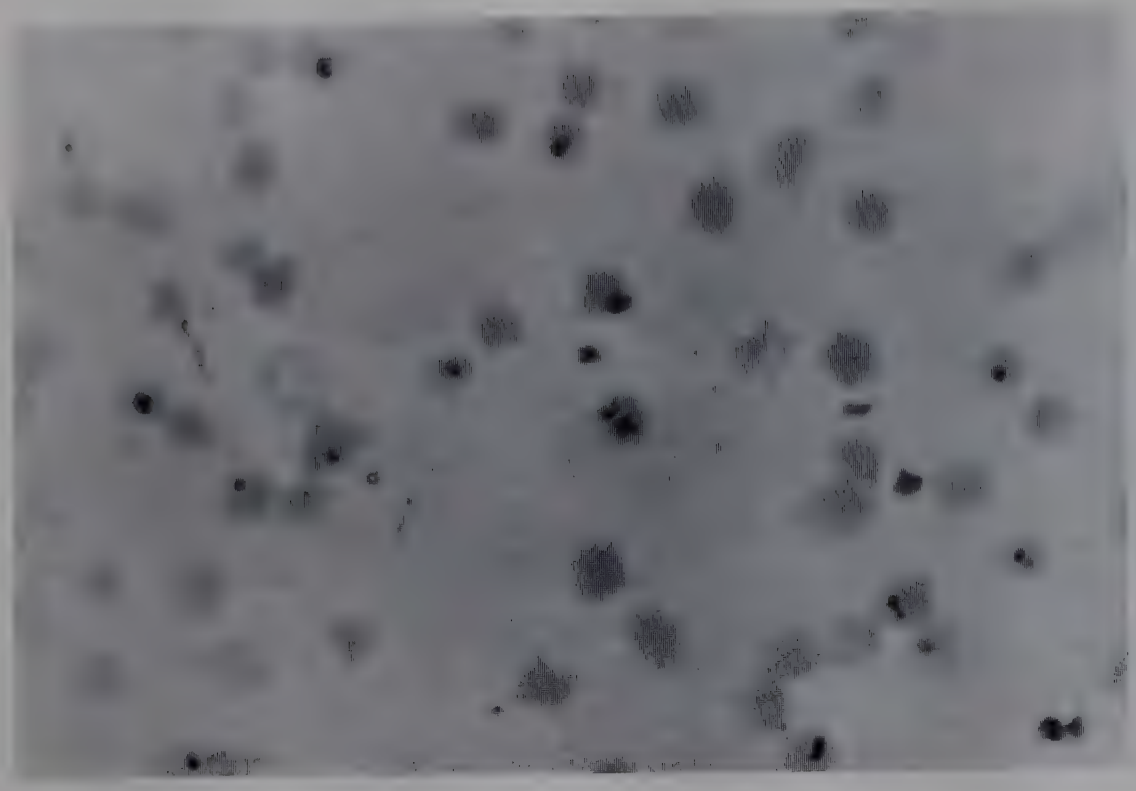
It should be borne in mind that because zebus are more resistant to tick infestation than European breeds, a situation that is epizootic for the combination zebu-*Boophilus*-*Babesia* may be enzootic for European cattle-*Boophilus*-*Babesia*. Humpless breeds of cattle will thus require more intensive tick control than zebus in the same area.

A feature of some tick-borne infections (e.g., *Babesia* and *Theileria* spp.) is that the infection is not passed on to the host as soon as the tick begins to feed; a few days may elapse before the infective particles in the salivary glands of the tick multiply and become mature. This so-called prefeeding period is especially important in the case of East Coast fever (*Theileria parva*). In situations where tick eradication is not feasible, dipping twice a week with modern acaricides that have a short residual effect may still prevent disease transmission. By this means, ticks that have attached after the last dipping will be killed before the end of the prefeeding period.

Babesioses

Most mammalian species are hosts to one or more species of *Babesia*. The only stage in the mammalian host that is known with certainty is the piroplasm that occurs in the red blood cells. Because the defence mechanisms in the host prevent the parasite from multiplying at a harmful rate, an equilibrium between the host and the parasite is reached and the parasite is thus able to maintain itself for an extended period. The situation may resemble that which occurs in trypanosome infections where certain antigens of the parasite, that stimulate the formation of protective antibodies by the host, change before the parasite is completely eliminated by these antibodies; new antibodies are then produced by the host, and the parasite changes its antigenic constitution again in order to maintain itself.

While there is some experimental



Left: Theileria parva **piroplasma in blood**

Right: Anaplasma marginale **in blood**

Far right: Babesia bigemina **in blood**

evidence of such antigenic variation in *Babesia*, it appears that these changes are not so numerous and so frequent as in some of the trypanosomes. *Babesia* infections seem to be eliminated by the host after varying intervals (sometimes a few years) if there are no new infections. As long as the animal is a carrier of a *Babesia* species, and sometimes for an even longer period, it is protected by its immune mechanism against new infections. This protection is not always complete because antigenically different strains of a species can occur, but it is usually sufficient to prevent fatal disease in cattle. Clinical, even fatal disease, is occasionally seen in carriers, when the defences are broken down by an intercurrent disease (e.g. in cattle, by rinderpest), or other causes of stress.

From an economic point of view the most important babesioses are those of cattle. The foremost of these is that caused by *Babesia argentina* (synonymous with *B. berbera*, *B. bovis* pro parte, *Françaiella caucasica*, and a few other names), which is usually transmitted by species of the tick genus *Boophilus*. As *Boophilus* spp. are one-host ticks (where moulting from larva to nymph and from nymph to adult takes place on the same host individual), transmission is normally from one generation to the next and the infection is passed on through the egg of the infected female to the larvae of the next generation.

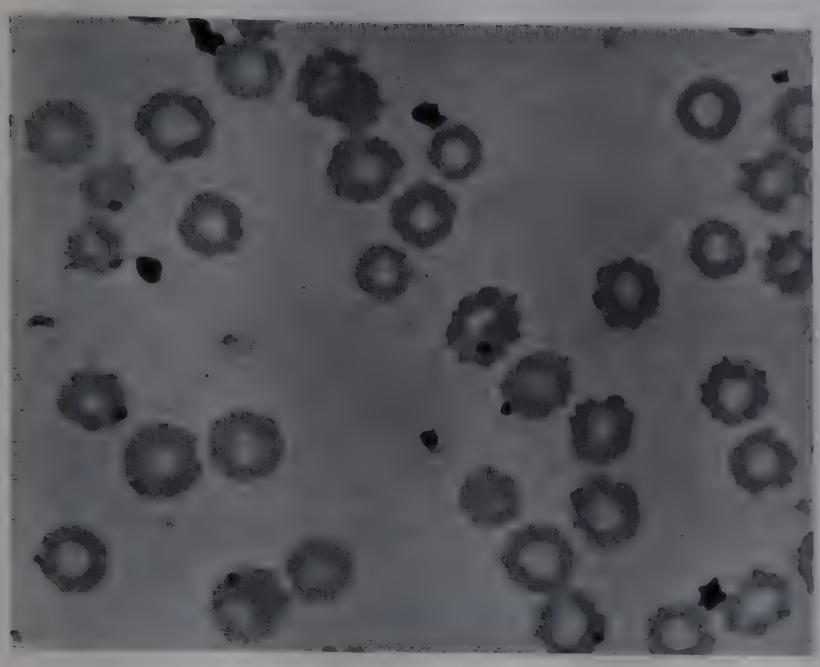
Babesia argentina is widespread in tropical and subtropical countries wherever *Boophilus* spp. occur, although there is at least one curious gap in its distribution: it appears not to have been reported in East Africa where both *Boophilus decoloratus* and *B. microplus* occur and research in blood parasites of cattle has been going on for a long time. Cattle of the zebu breeds are significantly less susceptible to the clinical effects of *Babesia argentina* infection (although not to the infection itself) than are cattle of European breeds (e.g., Daly and Hall, 1955). *B. argentina* is not only an important cause of disease in epizootic areas, but it is also one of the main causes of mortality in susceptible cattle imported from abroad.

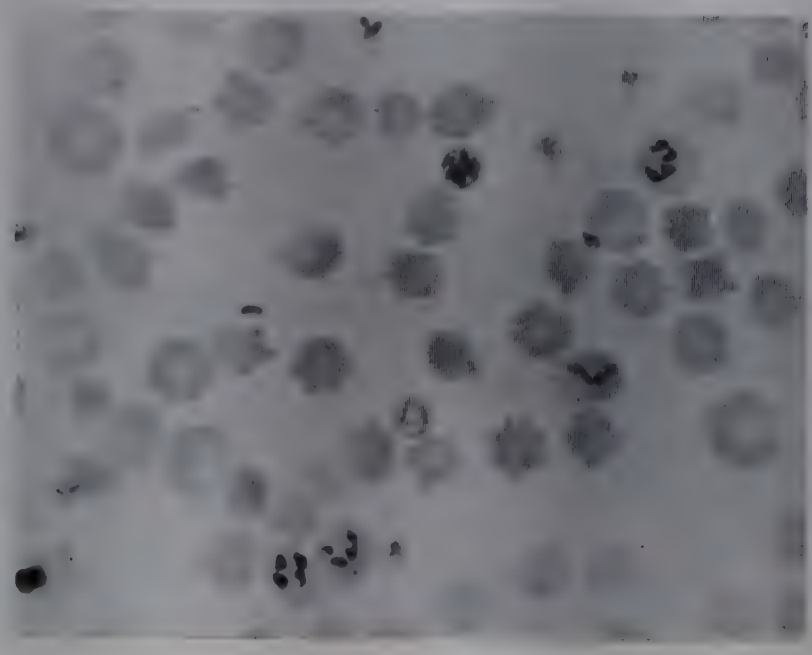
Babesia bigemina, another cause of babesiosis or redwater in cattle, has roughly the same distribution as *B. argentina* because *Boophilus* ticks are also among its most important vectors. The pathogenic importance of *B. bigemina* is less than that of *B. argentina*. Its special position in many textbooks and reports is perhaps due to the fact that it is much more easily diagnosed than *B. argentina* because of its large size and its occurrence in far greater numbers in the peripheral blood. It is also more amenable to treatment than *B. argentina*. Nevertheless, animals do die of *B. bigemina* infection, and immunization of susceptible animals before exposure may be recommended.

Other babesioses of cattle are more restricted in their distribution, and of less economic importance. Two species that may be mentioned are *Babesia divergens* (= *B. bovis* pro parte), transmitted by *Ixodes ricinus*, and *B. major*, transmitted by *Haemaphysalis punctata*. The latter parasite is almost as large as *B. bigemina*. The reports that suggest that *B. bigemina* is transmitted by *H. punctata* may be due to mistaken identification.

Theilerioses

Species of the family Theileriidae are widespread among ungulates. Transmission is from stage to stage and not through the egg to the next generation. The larva ingests infected blood, and after moulting transmits the disease as a nymph; if the nymph





feeds on an infected animal the infection is then transmitted by the next stage, the adult. One-host ticks, in which all three stages stay on the same individual host animal, are therefore not vectors. Trans-stadial transmission also means that those species of ticks of which the immature stages do not normally feed on the final host play no role in transmission, even though in the laboratory certain of these species have been shown to be capable of transmitting the disease.

The life cycle of the Theileriidae in the final host is more complex than that of the Babesiidae, in as far as the latter is known. After the infective particles are injected into the host during tick feeding, the first visible stages are the macroschizonts in lymphoid cells of the regional lymphnode. The macroschizonts contain a number of nuclei, and give rise to microschizonts. The microschizonts contain many small nuclei which after the microschizonts break up invade the red cells and form the piroplasms, the infective stage for the tick. After the regional lymphnode is invaded, other lymphnodes are also invaded, and lymphocytic cells containing schizonts can be found in other organs as well.

The most pathogenic of the Theileriidae is *Theileria parva*, the cause of East Coast fever in cattle. This disease is fortunately limited in distribution to eastern and southern Africa, and is of primary importance there as the most important cattle killer in many areas. The vector is *Rhipicephalus appendiculatus*, a three-host tick, and the distribution of the disease generally coincides with the distribution of this tick species. Other species have been proved capable of transmitting East Coast fever experimentally, but play no significant role in nature (e.g., Barnett, 1968).

The epizootiology of East Coast fever is different from that of the babesioses. The parasite has apparently not been adapted to cattle long enough to render it apathogenic in enzootic regions where there is a considerable calfhood mortality, even in indigenous zebu breeds. Although figures of calfhood losses of 30 percent or more have been reported, reliable statistics are not available. Mortality in epizootic situations (where tick numbers are too low to infect all young calves) can be catastrophic and depends on the proportion of immune animals and the size of the tick population which fluctuates from year to year as a result of rainfall. Mortality in susceptible adult cattle may be over 90 percent even in zebu breeds. Another difference from the babesioses is that, with some exceptions, recovered animals do not usually remain carriers of the parasite and are normally not infective to ticks.

In areas where *R. appendiculatus* occur, the African buffalo is a carrier of a theilerial parasite which is pathogenic to cattle and causes corridor disease in the latter. Buffaloes act as carriers of this parasite, and may remain infective to ticks for at least three years. On transmission to cattle, macroschizonts develop, but there are very few or no piroplasms, and the disease usually dies out in cattle. On a few occasions however it has been possible to transmit corridor disease from cattle to cattle with *R. appendiculatus* and even to transform the behaviour of the parasite in such a way that it resembles classical *Theileria parva*. Since the buffalo parasite, which has been given the name *T. lawrencei*, is serologically identical to *T. parva*, and since transformation into a parasite resembling *T. parva* is possible and also because a degree of cross-immunity between strains of *T. lawrencei* and *T. parva* occurs, it is likely that *T. lawrencei* of buffalo is the original parasite which has later

Captive African buffalo is studied for its role in cattle theilerioses. The dangerous horns of this animal have been removed to facilitate handling.

adapted to cattle after being introduced into Africa.

Recently transformed strains may give rise to the carrier state in cattle. The author shares the view with Barnett and Brocklesby (1966) that *T. parva* of cattle and *T. lawrencei* of buffalo are biologically different strains of the same parasite, which should be called *T. parva*, as this was the first name given. For the sake of facility, and taking into account the biological differences between *T. parva* and *T. lawrencei*, one might consider them as subspecies, and the classical cattle parasite would then be called *T. parva parva* and the buffalo parasite *T. parva lawrencei*.

Cross-immunity between different strains of *T. parva* is not always complete, and cattle recovered from disease caused by one strain may still die of another, although a partial cross-immunity may also exist. The total number of significantly different strains which exist in nature is still unknown. At the East African Veterinary Research Organization in Kenya, where East Coast fever immunization studies are being undertaken, it has been found that a combination of three strains, one a transformed buffalo strain and the other two from cattle, gives protection against all field strains tested so far in the laboratory. On field exposure of animals immunized with this cocktail, protection is not always complete, but preliminary results are encouraging. The technique of immunization employed is to infect the animals with infective particles derived from ticks, and to treat them during the early part of the incubation period with a tetracycline.

Research on immunizing with parasites grown in tissue culture has also reached a promising stage. Strains may also differ in virulence, although it does not appear to be conclusively known whether the degree of virulence is fairly stable in nature for a particular strain.

The second most important species of *Theileria* in cattle, with an even wider distribution, is *T. annulata*, which causes bovine theileriosis in northern Africa, southern Europe, the Near East and the Far East, including the Indian subcontinent. It is transmitted by species of the genus *Hyalomma*, of which *H. detritum* and *H. anatolicum* (= *H. excavatum*) are among the most important vectors. These are two- and three-host ticks and their immature stages occur on cattle. Although the mortality caused by *T. annulata* is on the average lower than that of East Coast fever, the disease is of great importance and is a major obstacle to the development of the cattle industry.

Immunologically different strains of *T. annulata* exist. Strain differences in virulence also occur, as in *T. parva*. Indigenous zebu breeds may be more resistant than imported breeds. Recovered animals remain carriers of the parasite. As far as is known, there is no wild host reservoir for *T. annulata*, but the domestic water buffalo can be infected. Although research on the disease has been going on for a long time, satisfactory answers to several epizootiological questions remain to be provided. Since there are different tick vectors, with a different biology from one region to another, its epizootiology will not be the same everywhere. Immunization is carried out in some countries with parasites grown in tissue culture, but more research is needed to evaluate the efficacy of present methods.

Theileria sergenti, a species occurring in cattle in the Far East resembling *T. annulata*, is transmitted by the three-host tick *Haemaphysalis longicornis* (= *H. bispinosa* pro parte = *H. neumanni*). It has been shown that *T. sergenti* is not transmitted by *Hyalomma* spp., while *T. annulata* is not transmitted by

Diluting cattle sera for serological testing for theileriosis

Haemaphysalis longicornis. The real pathogenic and economic significance of *T. sergenti* is still rather poorly documented.

The fourth named theilerial species of cattle is *Theileria mutans*. This was originally described as a nonpathogenic species from South Africa and the name has since been given to nonpathogenic *Theileria* of cattle in other parts of the world. It has been shown in South Africa to be transmitted by *Rhipicephalus appendiculatus*, as well as by *R. evertsi*. However, it has recently been found that the species called *T. mutans* in East Africa is not, or is only rarely, transmitted by *R. appendiculatus*, but that *Amblyomma variegatum* is an efficient vector. It remains to be demonstrated whether the East African *T. mutans* is really *T. mutans*.

The issue has been complicated recently by the discovery of apathogenic *Theileria* species of cattle in East Africa, transmissible by *R. appendiculatus*, but serologically different from both *T. parva* and the East African "*T. mutans*" (Burridge *et al.*, 1974, and unpublished experiments in Tanzania). It has also been shown that the East African "*T. mutans*" is not as devoid of pathogenicity as was generally accepted, and that fatal infections do occur; apart from its own importance as a pathogen, such fatal infections with high parasitaemias confuse the East Coast fever picture and must have been often diagnosed in the past as *T. parva*.

An apathogenic *Theileria* occurring in cattle in Europe has also been called *T. mutans* until now, but recent serological and morphological studies have shown that it is quite distinct from the East African "*T. mutans*". Transmission is by the tick *Haemaphysalis punctata*. Other parasites called *T. mutans* in the Far East and in Australia are transmitted by *Haemaphysalis longicornis* and are also unlikely to be the real *T. mutans*; since the vector is the same as that of *T. sergenti*, they may in fact belong to that species. Sera from Australian carriers, tested against East African *T. mutans* antigen, have not shown any reaction, but there is a serological relationship with the European *T. mutans* (unpublished data). The systematic position of the *Theileria* species in East Africa is not clear, and a comparative study with the South African *T. mutans* should be carried out.

Another apathogenic member of the Theileriidae is *Haematoxenus veliferus*, which is widespread in tropical Africa and in Madagascar. *Amblyomma variegatum* has recently been shown to be a vector in Tanzania. Natural infection has been found in wild African buffalo. There is no serological cross reaction with *T. mutans* or *T. parva*. Although parasitaemia may on occasion infest over 5 percent of red cells, it is unlikely to be incriminated as a cause of clinical disease.

Many points in the taxonomy and epizootiology of cattle *Theileria* remain to be clarified. In particular, the theileriosis complex in East Africa — where *T. parva parva*, *T. parva lawrencei* and *T. mutans* cause the "East Coast fever syndrome," and unidentified *Theileria* species and *H. veliferus* are also involved — will have to be unravelled.

In small ruminants at least three species are known: *Theileria hirci*, which is pathogenic, and two species, *T. ovis* and *Haematoxenus separatus*, which as far as is known at present are nonpathogenic.

Anaplasmoses

In the mammalian host the only known stages of *Anaplasma*, which are classified as Rickettsiales, are the forms in red cells where they occur as small darkly staining bodies.

The most important species is *Anaplasma marginale* in cattle, which has a very wide distribution in tropical, subtropical and even temperate zones. A less pathogenic species, *A. centrale*, was found in South Africa early in the century. Although immunological differences exist between both, they have certain antigens in common and *A. centrale* is extensively used to immunize against *A. marginale*. The morphological difference between the two species is in the site within the red cell. In the United States a new genus, *Paranaplasma*, with two species, has been separated from *A. marginale*, both on immunological and morphological grounds, but the validity of these species has not yet been generally accepted.

Transmission of *A. marginale* is normally by ticks, of which several genera and species have been incriminated. Although transmission through the egg has been reported from time to time, most workers have had negative results, and transmission appears to be mainly transstadial. *Boophilus* spp. can be incriminated on field evidence as major vectors, but the results from carefully controlled transmission experiments have been negative. As they are one-host ticks, it had of course been assumed that transmission would be transovarial, through the egg. However, positive results have recently been obtained with *B. microplus* in Madagascar and Australia in transstadial experiments, a small percentage of ticks apparently transferring spontaneously from one host animal to another during their cycle on the host (Uilenberg, 1970; Connell and Hall, 1972; Leatch, 1973). It has still to be determined whether transfer of one-host ticks from one host individual to another occurs frequently enough in the field to explain the vector role of *Boophilus*.

Besides ticks, biting insects may play a significant role in mechanical transmission in some circumstances, particularly where large tabanid flies might be the cause of seasonal outbreaks. Transmission experiments with the smaller insects, such as mosquitoes and stable flies, have in most instances given negative results. Anaplasmosis is also mechanically transmitted with injection needles and surgical instruments if these are improperly used on a series of animals. The epizootiology of anaplasmosis where *Boophilus* spp. are the main vectors can be compared to the simple model of *Babesia-Boophilus*. In enzootic situations, young calves, which are less susceptible than adults, all become infected. Although anaemia in young calves does occur occasionally (mainly in imported humpless cattle), on the whole there is not much of a disease problem, and the disease becomes important only in

Transmission studies are carried out by feeding infected ticks in earbags

epizootic situations and in susceptible cattle imported into infected areas. Despite the fact that the transfer of certain antibodies from the immune dam to the calf through the colostrum has been demonstrated, it remains to be conclusively proved that protective antibodies are included. It also has to be shown unequivocally that indigenous zebu breeds are more resistant than imported cattle breeds. After an animal has recovered from infection it probably remains infected for life, and is protected against the clinical effects of further infections. Although immunologically distinct strains might exist, their importance under field conditions is unknown. Strains of different virulence exist but the stability of the degree of virulence of a particular strain is not really known.

Cattle can be infected with anaplasms harboured by certain African antelopes, but there is no conclusive proof that these organisms are strains of *A. marginale*. Deer can act as reservoirs of *A. marginale*. However, anaplasmosis in cattle is just as prevalent in many regions without ungulates (e.g. in Madagascar, where it is enzootic) as in areas with game. Although small ruminants are susceptible to *Anaplasma ovis*, little research has been done on anaplasmosis of sheep and goats.

Cowdriosis

The causal agent of cowdriosis, *Cowdria ruminantium*, belongs to the Rickettsiales. The only stage known in the mammalian hosts is that occurring in endothelial cells of blood vessels. Diagnosis is easiest in smears of the cortex of the brain, where the organism can be seen in groups in the capillaries. As removal of the brain from a carcass is not often done in the field, the number of diagnosed cases does not reflect the actual importance of the disease.

Cowdriosis, or heartwater, is an important African disease of cattle, sheep and goats. It is transmitted trans-stadially by several species of *Amblyomma*, of which *A. variegatum* is the most widespread. The disease probably exists wherever *Amblyomma* spp. of ruminants occur in Africa, including the island of Madagascar, and possibly also in some of the Caribbean islands, where *A. variegatum* has been introduced. Proen vectors are *A. hebraeum* (southern Africa), *A. variegatum* (widely distributed), *A. pomposum* (a highland tick of eastern and southern Africa), *A. gemma* and *A. lepidum* (ticks replacing *A. variegatum* in lower rainfall areas of eastern Africa).

Due to difficulties in working with

the disease, comparatively little research has been carried out on cowdriosis. Until quite recently the organism could only be reliably propagated in ruminants and it has not been cultured *in vitro*. Since there is no serological test available, laboratory diagnosis is only possible after death.

Rousselot (1957) has described the situation in regard to cowdriosis in certain parts of western and central Africa as follows: "This disease exists wherever there is someone in the laboratory used to its microscopical diagnosis. If this person is transferred, the disease is transferred with him. It appears mysteriously at the site of his new assignment, after having disappeared from his previous post."

There is evidence of short-lived resistance of very young animals to the clinical effect of the disease, even in those born to susceptible dams. In situations with a sizable population of the vector, only a certain proportion of young adults is susceptible (Uilenberg, 1971), suggesting that perhaps a very small percentage of the tick population is infected. This may be due to the fact that the host remains infective to ticks for only a short period after recovery. It is possible that truly enzootic situations exist, without apparent disease, where vector numbers are very great, especially where indigenous breeds which are less susceptible are involved. But since control of such large numbers of *Amblyomma* is necessary to prevent festering wounds and abscesses caused by their long mouthparts, and since total eradication of these three-host ticks (which also feed on numerous other domestic and wild hosts) is almost impossible to achieve, the situation is usually an epizootic one in which the only control method is intensive dipping or spraying.

Tick control may be combined with artificial immunization, but present methods are still too cumbersome for application on a large scale in practical circumstances, at least as far as cattle are concerned.

Certain indigenous breeds of zebu cattle and sheep are more resistant than imported breeds, presumably through natural selection over the centuries; but zebu breeds imported from other continents appear to be as susceptible as European breeds.

Strain differences in virulence have been reported. Little is known with certainty about immunological differences between strains; partial differences have been reported.

Once the animal has recovered from infection, it is thought to be immune for several years. Whether the immunity is sterile or not is unknown, but recovered animals do not remain infective to ticks. Field observations indicate that animals may die suddenly of cowdriosis when exposed to certain stresses, but there is no experimental proof of a hypothetical carrier state.

Some wild African ruminants can be infected with heartwater and might play a role as reservoirs for domestic ruminants. However, the situation in Madagascar, where there are no wild ruminants and where heartwater is common and widespread, appears to indicate that the presence of wild reservoirs will not significantly influence the picture.

General commentary

Tick-borne diseases of cattle make havoc of the most ambitious plans for importing exotic breeds into tick-infested countries, or for upgrading a local breed by distributing improved animals from well-managed ranches that adopt good tick control. Many examples may be quoted of the disastrous results of importation or distribution where no effort was made to anticipate and prevent massive losses from theilerioses, babesioses, anaplasmoses or cowdriosis.

Animals should be immunized prior to exposure. If this is impossible, and if it is known that tick control will be inadequate, it is often a waste of time and resources to import or distribute them, unless they can be supervised closely by competent staff for immediate appropriate treatment when they become ill. But no treatment exists for theileriosis, and treatment is often too late in the case of cowdriosis.

The importation of susceptible cattle of breeds with no inherent resistance, costing large amounts of money, should be preceded by a thorough evaluation of the epizootiological situation regarding tick-borne diseases (and some other diseases, such as dermatophilosis, as well) at the point of destination, so as to assess the possibility of taking appropriate control measures. If this proves impossible, no importation should be made.

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VETERINARY TRAINING FOR THE TROPICS

with particular reference to Australian experience

by R.S.F. Campbell

The need to improve animal health and increase animal production is one of the most pressing issues in the world today. Nowhere is the need greater than in the tropics and this is creating an increasing demand for training and retraining at all levels of activity from the laboratory to the field. New educational centres in all continents are supporting the movement toward greater knowledge and efficiency in the animal sciences. Some of these have already been described in World Animal Review — for example, the training of livestock production specialists in Latin America (Moore, 1975).

The veterinarian with his broadly based university curriculum is active in many types of work, directed chiefly at the diagnosis and control of disease in livestock. Traditionally, food hygiene and veterinary public health, animal nutrition and breeding, and the development and standardization of drugs and vaccines, have also been within his (or her) area of interest. But more recently such topics as pollution, toxicology, conservation and the commercial production of fish have attracted significant numbers of graduates. Institutions are responding in different ways to these changing patterns.

Undergraduate education

A feature of the postwar world has been the establishment of many new faculties of veterinary science in universities in every part of the developing world. Their curriculum structure generally follows a broad standard pattern, and while this provides a framework for an undergraduate course, some changes in educational philosophy have been advocated (Campbell, 1975). The efficiency of the veterinary services — the chief objective of the training programme — would benefit if greater attention were paid to the following areas.

1. Social and economic structure of farming communities. Attention to this important area is long overdue in veterinary faculties in both temperate and tropical countries. A course covering this subject matter might usefully be offered in the last two years of the undergraduate curriculum, when the student has acquired some knowledge of agronomic and management methods for animals. Close collaboration with the university faculty of agriculture could be an advantage, since economic expertise is usually available there.

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Tropical pasture management can lead to increased production in dairy and beef cattle

The sociological background to animal production can only be taught by someone with an intimate knowledge of the people in the areas served by graduates from the veterinary school. Success or failure of a livestock programme may depend on the degree of understanding between the field officer and the owner.

2. Soil science and agronomy. Training in animal nutrition is incomplete without some knowledge of the total ecosystem. Since most ruminants are produced on grass, aspects of the soil-pasture-animal relationship should be introduced at an early stage in the course, preferably during first-year biology when the student is exposed to plant types, but continued later as part of the nutrition course itself. The need for training in agronomy is also urgent because of newer developments in the use and management of grasses and legumes, and the association between soil and plant systems and metabolic diseases in animals.

3. Animal production techniques: management, nutrition and breeding strategies. While aspects of these disciplines are already included in most veterinary curricula, usually during the middle of a five- or six-year course programme, greater emphasis could be given to them. This implies enlargement of some of the courses and more practical experience in the field. In the tropics the student may require expertise at two levels, to deal both with the traditional management methods that are not amenable to rapid change and with the more sophisticated production techniques that must be used with care on a realistic economic basis. The customary courses of animal management (zootechny), nutrition, and animal breeding and genetics offer the necessary base for incorporating new material. Many areas of interest claim inclusion: the management of improved tropical pastures; the use of irrigation; sugarcane, molasses and nonprotein nitrogen in ruminant nutrition; selection of breeds for optimal production and disease control; practical cross-breeding programmes. These are a few aspects of animal production in which the veterinarian working in the field should be well informed.

Integrated teaching and examination methods

The addition of new teaching material, however, always carries the danger of overloading the student in what is already a large and complex curriculum. The temptation to increase the total length of the course must therefore be resisted. It is usually possible — by skilful and guided use of textbooks, and reduction of other parts of the course —

to maintain a reasonable schedule of work, say 25 classroom hours per week in the first three preclinical years and 30 hours per week in the two clinical years. Reducing the number of lectures and increasing the discussion periods in which the student actively participates is a certain way of improving the learning process. Much has been accomplished in some schools by reducing the teaching time for anatomy and histopathology. Further efficiency can be obtained by integrated teaching and examination methods.

The close relationship among certain disciplines in the veterinary course provides an opportunity for planned multidisciplinary teaching. This not only has the advantage of a saving in time but also of giving the student a better perspective of his subjects. Anatomy-histology and physiology-biochemistry are a natural grouping of subjects, as are pathology-microbiology-parasitology-immunology. Such integration will require the breaking down of departmental barriers and the design of courses on a committee basis under a coordinating chairman. This is not always easy to accomplish, but the younger faculties in the tropics, being less fixed in their attitudes and still rather experimental, have the chance to become pioneers in progressive and more effective teaching methods.

Methods of student assessment are relevant in this context. In the past it has been common practice to examine in a subject after a relatively long period, one or even two years in some instances. A feature of modern teaching systems at all levels is the movement toward continuous assessment, that is, assessment of the individual student at more frequent intervals, using a variety of techniques such as essays, multiple-choice questions, practical work and case studies.

Veterinary training is very suitable for this method as the student's progress in theory, laboratory and field work can be monitored with acceptable accuracy and fairness, and assessment made of his knowledge and skills in smaller units of the course. Such a system has the added advantage of providing a feedback of information on the student's progress or lack of it, and the need for remedial action. Teaching staff must, however, avoid the common pitfall of subjecting studies to an excess of short examinations which can distract them from a proper appreciation of their subjects. Two subject assessments per semester is usually a reasonable goal.

Graduate training

The need for graduate training in the contemporary world is recognized by tropical and temperate countries alike. Particularly in highly technical work it has been estimated that the half-life of much of the information provided at undergraduate level is only about five years. That is, within the period, half the information previously acquired is out of date. It is therefore necessary to provide facilities not only for advanced training but also for updating the knowledge of graduates who have already been professionally active for a number of years. At present some of the most interesting developments are taking place in graduate veterinary training, and this is particularly true in Australia.

Advanced training in Australia

The establishment of a graduate school of Tropical Veterinary Science at the James Cook University of Northern Queensland in 1969 was intended to meet the needs of livestock industries both in northern Australia and in other countries. Northern Queensland is a microcosm of the tropics, containing within its area a diversity of environments ranging from semiarid scrub and grassland through savanna to areas of high rainfall, especially along the Pacific coast. The intrusion of new methods of agronomy and irrigation lends further variety to the scene and allows the observation and use of animals under many management systems.

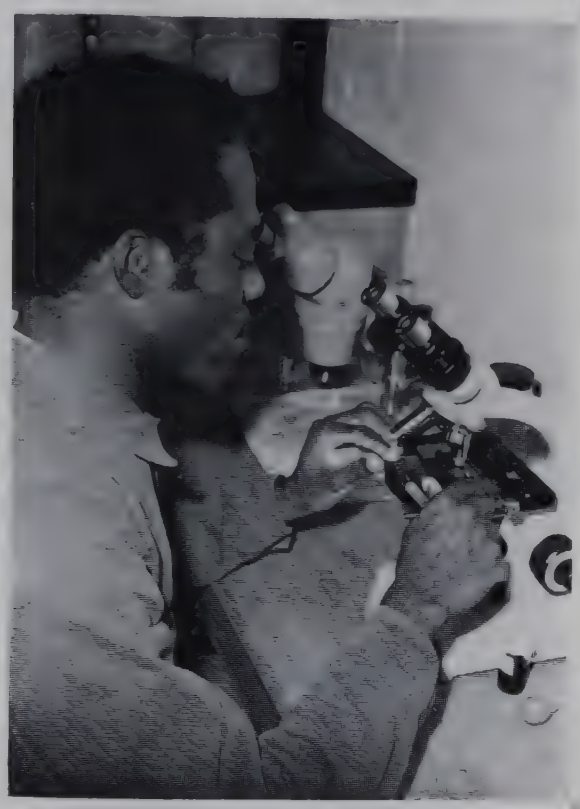
Advances over the past 20 years have introduced additional elements such as *Bos indicus* cattle and tropical grasses and legumes which are now being intensively developed under both experimental and commercial conditions (Stobbs and Thompson, 1975). The high degree of cooperation between the university and other regional organizations allows students access to various facilities for their course work or projects. Notable participants are the Queensland Department of Primary Industries (branches of Animal Health and Beef and Dairy Husbandry), and the Commonwealth Scientific and Industrial Research Organization (CSIRO), represented by divisions of Tropical Agronomy, Animal Health, Animal Physiology and others. Students can therefore draw on the experience of many scientists during their seminars, practical work and research.

The school at James Cook University comprises research and graduate training staff in both animal health and production, and their programmes are designed to allow as much flexibility as possible. Since the spectrum of interest of veterinary and allied scientists is wide, options are provided to meet many individual interests. These are summarized in Table 1, which outlines the courses available to M.Sc. and other students whose interests are equally divided between animal health and production sciences. Approximately half the current enrolment of 40 graduate students are from other countries.

In the past four years, 18 nationalities have been represented from all continents and currently include students from Bangladesh, Fiji, India, Indonesia, Kenya, Malaysia, Mexico, Nigeria, the Philippines, Thailand and Uganda. Their needs are met by the following programmes:

Programme	*Duration*
M.Sc. by course work and research	12 months
M.Sc. by research	2 years
Ph.D. by research	3 years
Intensive short practical courses (e.g., ranch management and beef production)	3-6 months
Ad hoc individual training	variable

Above: **Animal production would be greatly increased by the prevention of disease in young cattle, sheep, swine and other livestock. Here a piglet is being tested for virus infection.**



Above: **Control of parasitic diseases is one of the major objectives in tropical countries**

Left: **Training in laboratory methods is necessary for the efficient use of extension services and research**

Below: **Meat inspection and veterinary public health services ensure quality control of food. They also provide information on the incidence and geographic distribution of animal diseases.**

Below: **Infertility in cattle has many causes. Training must include a variety of techniques.**

The periods quoted may be extended if required. With the exception of the M.Sc. course, for which a previous veterinary degree is a prerequisite, the programmes are open to graduates in other disciplines (e.g., agriculture, zoology and biochemistry) and the short courses and *ad hoc* training may be given to nongraduates who work in an appropriate field. Each student is assigned to a supervisor for guidance in the planning and execution of his work. Among international students there is an increasing demand for the M.Sc. Course in Tropical Veterinary Science, which combines seminars, practical work and research in such a way that a considerable degree of individual training can be given. The system applies to students who may be destined to work in diagnostic medicine, animal production, research, teaching and other activities. Table 1 indicates the structure of the course, which is distributed over a continuous 12-month period of study. With this curriculum, the student obtains a broad review in the first term of the present situation in key disciplines such as applied microbiology and nutrition where many new ideas are current.

In the remainder of the course he can devote himself to a special field of interest and acquire a comprehensive body of knowledge and practical experience in the laboratory and the field. Students are also given guidance in writing reviews and scientific papers. Each part of the course is geared to the contribution he will make on proceeding to his next professional assignment. The use of elective courses allows a choice of topics in animal health or production or, if the graduate wishes, in a combination of these; for example, animal breeding and infectious diseases. In the research component there are opportunities for working with groups of experimental livestock and familiarization with practical techniques of management, nutrition, diagnosis and disease control. Some of the problems studied by students are listed in Table 2.

Experience with this system since 1972 has shown that the student can benefit in the following ways:

— Thorough appreciation of current knowledge in a relevant field.
— Acquisition of techniques which can reasonably be applied in that field.
— Appreciation of the total ecosystem and the interaction of such forces as climate, soils, pasture, breed of livestock, nutrition and pathogenic agents in various tropical environments.
— Awareness of other disciplines which may contribute to more efficient laboratory or extension services.
— Information on the organization and deployment of extension services, and adviser-producer communications.
— Training in information retrieval.
— Experience in scientific writing and reporting and the use of audio-visual aids.

In selected projects, access to more advanced technology in analytical work or computers can be given, but emphasis is not usually laid on these. The total experience which may be obtained in six months by graduate students is illustrated by the research "profile" in Table 3.

Group training

In addition to the training of individual scientists in applied techniques, several new schemes are being offered by the Australian Government and universities to groups of veterinarians and allied workers. These are in progress each year, both in Australia and in Southeast Asia.

The Australian-Asian Universities Cooperation Scheme provides short-term courses annually in the agricultural and veterinary sciences in the recipient country. Groups of workers are assembled at a conference centre to take part in an intensive programme of seminars and practical work for three or four weeks. The opportunity is thereby given to update knowledge, acquire practical skills and in some cases plan and carry out field investigations on a follow-up basis. Diseases of cattle, poultry management and tropical agronomy were among the topics presented recently.

A supplementary benefit of the

Table 1 **Graduate courses in tropical veterinary science (12-month programme)**

Term 1	Term 2	Terms 3 and 4
Review *(a) Animal health:* Tissue responses Infectious diseases Epidemiology Diagnostic methods *(b) Animal production:* Climatology Soil science Tropical agronomy Ruminant nutrition Animal breeding Statistics Information retrieval	Elective courses Pathology Microbiology Parasitology Nutrition Reproduction and applied genetics Tropical production systems	Research project [1] Literature seminar Research seminar

[1] The research project includes a comprehensive literature review, design and execution of experiments, analysis of results and the preparation of a scientific paper and thesis.

Table 2 **M.Sc. research topics for the 12-month programme**

Animal health	Animal production
Pathology	**Nutrition**
Genital pathology in cattle	Digestibility of tropical grasses
Infectious nephritis	Supplementation techniques
Bovine mastitis	Nutritional value of sugarcane and sugar products
Equine swamp cancer	Techniques for rumen function studies
Microbiology	Interaction of nutrition and helminthiasis
Leptospirosis	Trace element metabolism
Melioidosis	**Reproduction**
Improved serological techniques	Thermal stress and spermatogenesis
Porcine parvovirus infections	Analysis of herd fertility
Equine infectious anaemia	Effect of genital infections
Parasitology	Age effects on genital structure and function
Immunity to *Babesia*	Breed performance comparisons
Gastrointestinal parasitism, epidemiology and control	
Other	
Zoonotic diseases of wildlife	

scheme is the transmission of information by participants, most of whom are university staff, to their own students at various institutions throughout the recipient country. A similar programme supported by the World Bank and the Australian Government, offered by the Tropical Veterinary Science Department at James Cook University, is training workers in beef and dairy cattle production. Again, this annual course is structured to contain some formal instruction in breeding, nutrition, disease control and range management, followed by field experience on experimental and commercial cattle stations. The emphasis is on what is useful and practicable.

The establishment of the new Australian Development Assistance Agency has provided an additional impetus to international training in the agricultural and livestock fields generally. As well as promoting individual and group training within Australia, it is, with CSIRO, coordinating the establishment of a major Centre for Animal Research and Development near Bogor, Indonesia (Wolfe, 1975). Among the projects to be carried out there will be aspects of buffalo and poultry management and production. From this institute, as in complementary centres in Australia, Africa and South America, a flow of highly trained personnel and applied research can be expected in the decades ahead, with a resulting boost to animal production.

A national development chain is made up of relatively few links: government recognition, financial backing, good communications between technical personnel and the producer, and education. Not the least is a sound, well-equipped educational system. The veterinary schools and allied agencies can make a very significant contribution to the supply of animal protein if they are given adequate support. It is up to international organizations and individual governments to see that this is done.

Table 3 **Course in tropical veterinary science Project structure** [1]

Topic	Parasitology and nutrition
Objective	To study the effects of gastrointestinal parasites and dietary supplementation on production in beef cattle on improved tropical pastures.
Techniques	(i) Management of weaned cattle in groups (ii) Estimation of weight gain (iii) Molasses and trace element supplementation (iv) Worm egg counts (v) Biochemistry of blood (vi) Anthelmintic treatment strategies (vii) Statistical analysis
Findings	(i) Parasites unaffected by molasses (ii) Copper-molasses and cobalt-molasses treatments improve weight gain (iii) Positive interaction between molasses supplementation and anthelmintics
Outcome	Determination of optimal production system in a wet tropical area

[1] From Copeman *et al.*, 1975; Sumbung *et al.*, 1975.

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TURKEY P

by G.A. Clayton and C. Nixey

The long-term survival of a turkey industry on any significant scale is dependent on its ability to produce meat that is competitive in price with that from other forms of livestock. The main variable cost affecting meat production is feed, and with turkeys this may range from 70 to 80 percent of production costs at current feed prices. Much of the feed consumed by turkeys, other poultry species and pigs could be consumed directly by man, and there does not appear to be much prospect of using cheaper alternatives.

Blaxter (1971) estimated that it requires 45 lb of barley (or its equivalent) to produce 1 lb of lean meat from sheep, 30 lb for beef, 15 lb for chicken and 12 lb for pigmeat (2.2 lb = 1 kg). However, his conclusions, based on a whole farm situation, are rather out of date, particularly in regard to the chicken. His chicken data were based on figures and conversion ratios that are poor by current standards; he also excluded elements such as skin, which in poultry is an edible source of protein. If these factors are taken into account the figure for chicken would work out at about 10 lb and the figure for turkeys would not be very different.

Nevertheless, the general conclusion that meat production based on grain feeding is an extravagant use of available resources is inescapable. But it should be noted here that although ruminant animals can produce meat from feed that cannot be consumed directly by man, they do compete with man insofar as the concentrate part of their diet is concerned, as well as in their utilizing of pasture land that might otherwise be used for arable cropping.

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Feed conversion efficiency

The size of any animal industry must be influenced by the efficiency of the species concerned in converting the protein in the feed into high-grade animal protein for human consumption. Table 1 sets out species differences in efficiency of protein conversion. It can be seen from this table that milk production from dairy cows (and possibly from milch goats) and egg production from poultry are superior to all other forms of livestock production in their efficiency in converting feed protein into animal protein for human consumption. In the mean efficiency league for meat production are broilers and turkeys, which are vastly superior to pigs, and these in turn are well ahead of ruminants. On the assumption that we rear farm animals to supply us with high-class protein, the comparative efficiency of the different species in meeting this requirement is surely the best way of deciding how to allocate scarce resources.

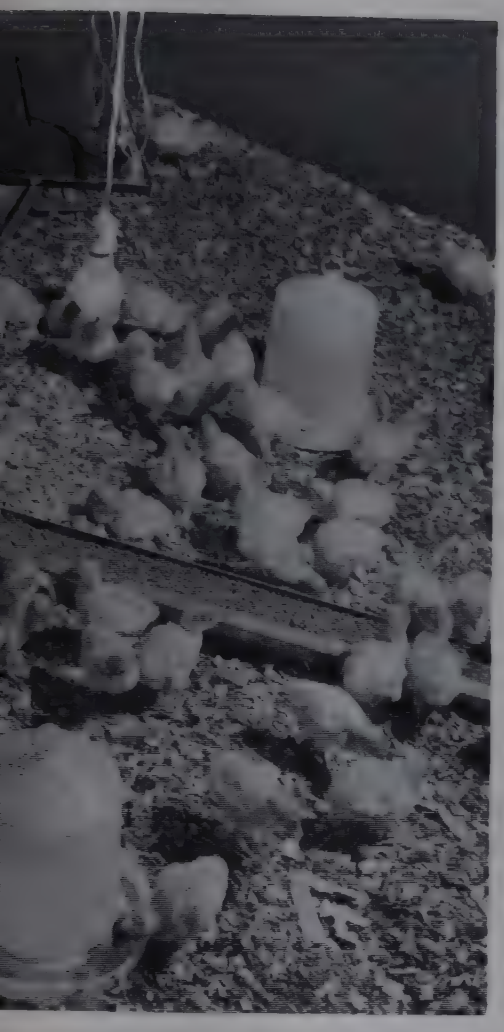
There are good reasons for the feed conversion efficiency of the turkey shown in Table 1. The industry owes its existence to the rapid advances made in husbandry, disease control, nutrition and genetics. From being

Floor brooding. A good start in life is essent near the brooder and exclude draughts. Food

a rare luxury dish the turkey now enjoys the not altogether unqualified distinction of sharing pride of place with the broiler as the cheapest source of meat available. Some indication of the progress made in the last 20 years is shown in Table 2.

This table contains results from various sources and these are therefore not valid for making precise statements about the changes that have occurred. However, there is no doubt that the three major changes reflected in these data are real enough. The first is the change of

ODUCTION



rdboard surround to keep the poults be within easy reach.

Tier brooding. This has a higher labour requirement than floor brooding but does not demand much husbandry skill.

Table 1 **Species differences in efficiency of protein conversion**

		Milk [1]	Eggs	Broilers	Turkeys	Pigs	Beef [1]	Sheep [1]
Feed consumed	*kg*		47.5	4.0	29	272		
Parents' feed [2]	*kg*		0.5	0.5	2	77		
Total feed	*kg*		48.0	4.5	31	349		
Feed protein	%		15.6	19.5	19	14		
Total protein	*kg*		7.5	0.87	6	49		
Product	*kg*		14.7	1.9	10	91		
Saleable	%		100	70	85	75		
Edible	%		95	74	70	48		
Protein	%		12.8	19	20	20		
Protein yield	*kg*		1.8	0.2	1.2	7		
Protein efficiency	%	23	24	22	20	13	6	3

[1] From Holmes, 1971. — [2] Parents' feed divided by number of offspring.

the white turkey from a small and relatively minor variety to its present dominant status. This was achieved by selective breeding, and the substantial size gap between the white and bronze forms has now been entirely eliminated.

The second change is the large increase in growth rate in the last 16 years, again a result of intense selection. Associated with this has been the third major development, namely the reduction in the amount of feed consumed per unit of liveweight gain. This change is best seen in the perspective that if no genetic improvement had taken place the current feed bill would be some 30-35 percent greater for the same output.

Although it is not possible to make similar claims for improvement in fecundity over the same 20-year period — and good statistics are hard to come by — it is likely that there has been some increase in the average number of poults produced per hen housed. It should be noted in this connection that the industry has moved from seasonal to year-round production, and there has also been a large increase in the growth rate of turkeys. These developments are not conducive to high fecundity and therefore the breeders deserve considerable credit for succeeding as well as they have done.

Future trends

As far as the future is concerned there is little doubt that as long as meat continues to be eaten, the turkey, with its greatly improved efficiency, will remain a major contributor. A comparison of Israeli and United Kingdom meat consumption statistics is of interest in suggesting possible trends. Table 3 shows that poultry contribute some 65 percent of all the meat consumed in Israel compared with 17 percent in the United Kingdom. For turkey the figures are 12 and 2 percent respectively.

These differences may be attributed in large part to the harsher economic climate in Israel, which favours the development of the poultry industry,

whereas in the United Kingdom the meat consumption pattern is distorted by discrimination against poultry in the heavy state subsidization of the ruminants. As economic pressures grow, the trend in the United Kingdom and in the rest of the world must surely be toward increased consumption of poultry at the expense of the other animals.

The rapid expansion of the turkey industry in North America, Europe and Israel over the last four decades is evidence of the climatic adaptability of the species, the solution of technical problems which had previously been a barrier to large-scale production, and the great improvement in efficiency of feed conversion which has resulted from selection. What had earlier been a luxury dish associated with the festivals of Christmas and Thanksgiving has now become one of the cheapest meats for everyday human consumption.

Only the high-fecundity species such as turkeys and chickens, producing 60 to 120 progeny per female per year, can make a significant impact on meat requirements on a national scale in as few as three to five years. For turkeys the effective factor would be of the order of a thirtyfold increase in production per year to attain whatever level of throughput was ultimately desired.

Another important factor is the capital cost involved. With poultry there is no doubt that the capital cost per unit of meat produced is substantially lower than for any other form of livestock under intensive production. Another advantage favouring poultry as a source of meat is its virtually universal acceptance, and the fact that the units are relatively small is sometimes an important consideration, especially in hot countries where cold storage and refrigerated transport facilities are limiting.

Advantages of the turkey over the broiler

An advantage possessed by the turkey over the broiler is its capacity to attain much greater weights without a serious decline in efficiency of feed conversion. Turkeys are killed profitably over the age range of 10-24 weeks, providing considerable flexibility in meeting market demands. The larger older birds not only have a much lower evisceration loss, but are suitable for butchering operations and the sale of meat or further processed products.

In the case of chickens grown for meat the feed cost per unit of liveweight gain increases sharply after eight to nine weeks of age, but this effect is not nearly so marked in turkeys until a much later age. The comparison would become even more favourable to turkeys if it were made on the basis of dressed weight or yield. In an eight-week-old chicken dressing loss may be as high as 30 percent, but in turkeys this loss decreases steadily with age to as low as 15 percent after about 18 weeks.

Table 2 **Changes in liveweight gain and feed conversion in turkeys**

Year	Age (weeks)	Type	Liveweight (lb)	Feed conversion per unit liveweight gain
1957 [1]	20	Bronze	14.70 ♂♂ 10.74 ♀♀	3.98
1957 [2]	20	Bronze	18.16 ♂♂ 13.14 ♀♀	4.16 4.52
		White	14.39 ♂♂ 9.11 ♀♀	4.41 5.44
1959 [3]	20	Bronze	19.9 ♂♂ 13.9 ♀♀	? ?
1973 [4]	20	White	25.6 ♂♂ 17.5 ♀♀	2.75 3.08

[1] McDonagh and Bannigan, 1957. — [2] Quarterly Poultry Bulletin, 1957. — [3] Council of American Official Poultry Tests, 1959. — [4] Authors' observations.

Versatility of the turkey

Breeders have exploited the versatility of the turkey by producing strains specially adapted to particular markets. Broadly they comprise two types, large and small. The larger strains are faster growing and show lower feed costs per unit of weight gain, but are not always satisfactory in conformation and finish if killed at very young ages (8-12 weeks) to supply market demands for small (2-5 kg) products. The larger strains are undeniably more efficient in terms of lean meat yield per unit of overall cost (of which feed is the most important item), but substantial numbers of the smaller types are produced in North America and western Europe because of consumer demand.

Turkeys are raised in a wide range of climates, and not surprisingly there is a wide range in methods of housing them. In temperate climates housing on larger units is sophisticated, using buildings in which it is possible to control the environment, i.e., temperature, day length, air flow, etc. In this type of housing turkeys are brooded on the floor and remain in the same house throughout life. An alternative system to the controlled environment house is to brood turkeys in tier brooders until three and a half weeks, and then move them on to the floor, or into wire floored coops known as hay boxes, until eight weeks of age when they are placed in open-sided houses known as polebarns. Due to the high labour requirement this method has gone out of fashion in Europe and North America, but it may still be useful in other countries.

In hot dry climates with sandy soils, as in certain parts of the United States, turkeys are fattened on the range quite successfully after the initial brooding period. In wetter climates or on heavy land this is

not recommended. A soil-borne parasite known as the gapeworm (*Syngamus trachea*) can cause severe problems.

The feeding of growing turkeys

As protein is an expensive part of the diet, no more should be fed than is necessary to allow the animal to grow as fast as it is capable of doing. With the modern turkey, which grows extremely rapidly, it is advisable to make several changes in order to minimize the feed cost per unit of liveweight produced.
Table 4 is intended as a guide to the changes that should be made at various ages. The protein level is extremely high in the early stages and drops rapidly as the birds mature. The metabolizable energy in the ration should be maintained at approximately 2 800-3 000 kcals/kg. Variations from this norm would depend on the strain of bird used and the size and finish required at a given age or weight. Many details of formulation are influenced by changes in costs of ingredients, and the nutritionist must be allowed to use his skills in the important exercise of least-cost formulation. All that can be emphasized here is the vital importance of correctly formulated and controlled nutrition, without which no turkey-growing operation can hope to succeed.

Disease control

Great advances in the control of turkey diseases have been made in the last 30 to 40 years, and the growth of the industry has only been possible as a result of these. Without expert veterinary advice and control of prophylactic and therapeutic procedures no turkey venture could hope to succeed in the long term.
The traditional diseases of the turkey were blackhead (*Histomonas meleagridis*) and coccidiosis (*Eimeria*). Both of these have been conquered, chiefly by the routine addition of suitable drugs at prophylactic level to the feed. Several alternative drugs are available and they are nearly all equally effective.

Table 3 **Per caput meat consumption in Israel and the United Kingdom, 1972/73**

		Israel [1]	U.K.[2]
Beef	*kg*	17.6	20.0
Sheep and goats	*kg*	1.1	9.3
Other	*kg*	2.2	[3] 23.4
Poultry [4]	*kg*	39.3	12.2
Turkey [5]	*kg*	7.5	1.6
Poultry	*(% of total)*	65	17
Turkey	*(% of total poultry)*	19	13
Turkey	*(% of total meat)*	12	2

[1] Israel, Ministry of Agriculture, **Development of Israeli Agriculture 1959-73**, Statistical Series, Part 1, Hakirya, Tel Aviv, January 1975. — [2] **M.L.C. Market Survey Quarterly**, Summer 1973. (P.O. Box 44, Bletchley, Keynes MK2 2EF.) — [3] Including pork and bacon. — [4] Including turkey. — [5] Estimated.

With the increase in the size of operations and the use of intensive housing, the mycoplasma organisms came into prominence, particularly *Mycoplasma gallisepticum*, and caused severe respiratory problems. The organisms were transmitted through the egg which meant that their eradication was difficult. However, several major turkey-breeding companies in the world are now free of *Mycoplasma gallisepticum*. In the establishment of a new enterprise, it is essential that clean stock be purchased.
Another egg-transmitted organism, *Arizona paracolon*, is widespread in North America. However, several countries in western Europe with strict quarantine regulations, such as the United Kingdom, Ireland and Sweden, have succeeded in remaining free of this disease, which causes high mortality in young birds. Control is possible by the use of drugs injected into the poult at hatching time. Again, where a new entreprise is being set up it is advisable to ensure that this organism is not introduced, as it is similar to the Salmonella group of organisms and can survive for long periods in farm buildings and in the soil.
Fowl cholera (*Pasteurella multocida*) occurs sporadically. At times it can cause very high mortality, at others the losses are minimal. A vaccination policy can be used, but as there are many strains of pasteurella which can cause problems the vaccine cocktail of strains cannot guarantee that infection will not occur. Good sanitary practices will reduce the risk of an outbreak occurring. Wild birds should be prevented from gaining access to the birds' houses or water. Different ages of birds should not be mixed together. Farms should periodically be depopulated.
Organizations using clean stock and good sanitary practices experience very few serious disease problems. However, if the stock carries an egg-borne disease, and if the birds are stocked intensively, in farms not practising a depopulation period, losses due to disease can build up to serious proportions.

The management of turkeys

A turkey cannot be managed on the principle that it is "just a large chicken," as several chicken companies

Table 4 **Protein requirements of a growing turkey**

Age (weeks)	Protein (%)
0 - 3	30
4 - 6	28
7 - 10	24
11 - 17	18
18 - 20	14
21 -	12

that have entered the turkey business have found to their cost.

Turkey poults are more sensitive to brooding management than young chicks. It is essential to ensure that the poults are happy with the brooder temperature. This can be ascertained by their behaviour and spread under the brooder. In general the number of poults per brooder should be well below the usual chick number.

Unless both sexes are being killed very young, it is almost always essential to rear the sexes separately from the time they are a day old. This enables stocking rates and feeding programmes to be adjusted accordingly. Also, because of the considerable size difference between the sexes, the hens grow much better if separated from the stags.

There are specialized skills to be learnt for managing breeding stock. Turkey breeder hens require a short day length, which calls for the use of controlled environment housing to ensure that they commence lay at the correct age. Although some breeders are making progress in eradicating broodiness from their stock, it is still very much a management skill to reduce the effects of broodiness to ensure good egg production, particularly as most turkey breeder hens are kept on the floor.

The progress made in increasing body weight and breast width has meant that the fertility achieved by natural mating is not very good, so it is normal practice to inseminate all hens artificially. If this is done correctly it will achieve very good fertility, but as with all the skills involved in managing breeding turkeys the results are only as good as the staff producing them.

Range rearing can be used in hot climates with dry sandy soils

The deboning or portioning of the turkey does not require expensive equipment, only a sharp knife and a skilful operator

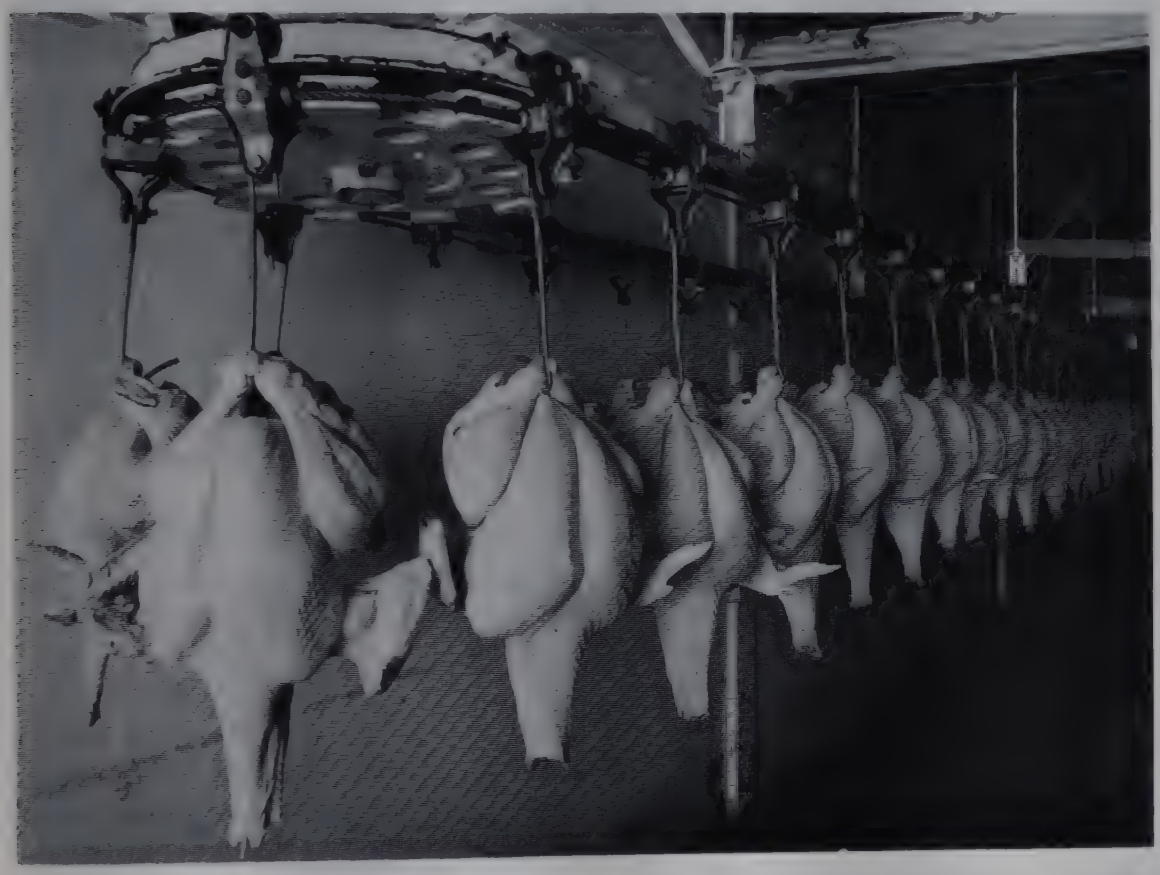
Processing turkey meat

The methods of slaughter, dressing and preparation of turkeys are similar to those employed for chickens. The form in which turkey meat is sold to the public, however, varies from country to country.

In Israel, which has by far the greatest consumption of turkey meat per head of population, turkey meat is used so that it can replace all the traditional red meat products (e.g., turkey breast steak, legs of turkey, turkey sausages, etc.). In the United States, turkeys are sold frozen oven-ready, and are also further processed into turkey meat rolls and roasts. In western Europe, in addition to frozen oven-ready turkeys, the birds are sold fresh with only their feathers removed. In some Mediterranean countries, such as Spain and Italy, turkeys are butchered and sold as meat in the same way that a pig, a lamb or a bullock is treated by a butcher. The turkey is therefore adaptable to all local traditional meat market requirements.

Birds marketed whole are usually in the 2.5 to 6 kg range, which in-

Polebarn rearing. The need for generous floor space becomes apparent as turkeys approach maturity.



Much progress has been made in breeding for improved growth rate, feed conversion and meat yield.

volves killing birds from 10 to 16 weeks of age. If the turkeys are to be cut up the males should be grown to 10-14 kg, killing at 20-24 weeks. The females, which mature earlier, can be processed at younger ages, whole or cut up as the market demands. Because of their versatility it is usually advantageous to grow the sexes separately.

A new enterprise

When a turkey industry is established in a country, the size of the project will probably be limited to the amount of turkey meat that can be sold. As it is a new product, at the start the market is likely to be small. As production techniques have to be learnt, it is best to begin by purchasing day-old turkeys for fattening from one of the world's large turkey breeders, who will also be able to supply the technology so vital to a new undertaking. As skills are acquired, and the market for turkey meat expands, the next stage would be to build a hatchery and purchase hatching eggs instead of day-old poults. Ultimately breeding farms would be built to produce the hatching eggs from parent stock purchased from a reputable turkey breeder.
The alternative is for a government, recognizing the potential of the turkey as a source of animal protein, to purchase a package deal project to establish the industry. This would cover breeding stock, technical information, house designs and the expensive fixed equipment involved in processing and incubation. The turkey lends itself to cooperative enterprises, with the state providing the processing station and the hatchery, and private farmers growing the turkeys. The raising of turkeys can be fitted into most farm work schedules easily, and provides the farmer with a valuable source of extra income without the need to increase the area of the farm.

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Lessons from a survey of successful experiences in assisting THE SMALLHOLDER LIVESTOCK PRODUCER

by E. Hunt McCauley

A large number of individuals and institutions are involved in the design and implementation of development projects which have as their objective the improved agricultural production of smallholders. However, sustained benefit to large numbers of smallholders has not occurred for a variety of reasons, usually related to institutional rather than to technical inadequacies.

In 1973 a survey of successful experiences in assisting the smallholder livestock producer was conducted with a view to drawing conclusions that might be useful to the World Bank Group in the design of development lending programmes. The survey was aimed at defining the positive elements and the problems encountered in smallholder livestock development efforts.

In a desk study, some 60 livestock development projects or activities were examined by evaluating written material and by interviewing experts in agricultural development from various institutions. Kenya and India were selected for field study. The results are discussed in this article.

Men and women of all castes line up together to sell milk to the Ajarpura Cooperative in Gujarat, India

The smallholder milk producers' cooperative organizations in Gujarat, India

The Kaira District Cooperative Milk Producers' Union Ltd. (the Kaira Union) is in the city of Anand in the state of Gujarat, some 320 km north of Bombay. This union is a federation of 783 village cooperative societies having a total of 225 000 member families. Most of these member families own and operate small plots of land (0.4 to 2 ha) and have from one to five buffaloes. The Kaira Union, formed in 1947, is the oldest union in Gujarat. Since then five other unions have been formed and operate in almost identical fashion.

Recently these six unions were brought together into a federation of unions. The main function of this federation is to develop new markets for buffalo milk, purchase certain inputs at quantity price reductions, manage the Gujarat milk grid, and assist in the development of other unions in Gujarat. The operation of the Kaira Union has been so successful that the Government has asked that it be used as a model in many other areas of India, and has commissioned a group of Kaira Union leaders to work out plans for the spread of this system in conjunction with experts from FAO and the World Bank.

Under the direction of the Kaira Union leadership, the assistance of external aid agencies has been used

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This article stems from the report to the World Bank on the *Survey of successful experiences in assisting the smallholder livestock producer.* The survey was done by E. Hunt McCauley, consultant, under the supervision of Don Stoops, Livestock Adviser of the World Bank. Mr. McCauley is at the College of Veterinary Medicine, University of Minnesota, St. Paul, MN 55108, United States. Copies of the full survey report may be obtained from Mr. Stoops at his address: The World Bank, 1818 "H" St., Washington, D.C., 20433, United States.

As described by Robert McNamara, President of the World Bank, in his speech to the Board of Governors in Nairobi, September 1973: "A smallholder is a rural inhabitant who farms less than 5 hectares or who is in the lower 40 percent of the population who receive only 10-15 percent of the total national income. In most cases, the smallholder is a crop and animal agriculturist."

to the greatest effect. Assistance from FAO, UNICEF, and the Government of New Zealand led to the erection of the processing plant at Anand. The United Nations/FAO World Food Programme provided powdered milk and butter oil, which generated funds for the development of smallholder milk cooperatives and enabled the Kaira Union to supply milk to the city of Bombay. The basic idea of this project, which has come to be known as "Operation Flood" was to convey consumer rupees spent in Bombay to village buffalo owners in Kaira. This external assistance has made a major contribution to the success of the idea. However, without the well-organized and coordinated marketing system, such aid would have had much less impact.

The village cooperative society and the villager

The essence of the Kaira Union is in the day-to-day operation of the cooperative societies which it serves. These societies are village milk-marketing organizations, governed by people elected by the villagers and operated by local workers who are paid out of milk sales. Besides the marketing activities, the societies function to provide inputs of concentrate feed, AI service and emergency animal health care. They also carry out certain group social benefit projects and act as vehicles for the extension of technical and social welfare information.

Individually these societies are tightly organized, and are woven closely into the organization of the union that serves their particular area. The society, however, does not attempt to restrict the sale of milk to markets outside the society. The village has a free milk market, but the villagers sell most of their buffalo milk to the society because the union price offered throughout the year by the society benefits the producer in the long term.

The society forms a centre for village cohesiveness and gives the villagers a sense of control over their destinies. The villagers can allocate society funds for charity, and to build schools, water supply facilities, approach roads and medical dispensaries. The society has been an equalizing force in the social structure. Women and men of all castes line up together to sell milk — once an unheard of occurrence.

The union is the vehicle by which villagers control their own milk market and compete with the private contractors to whom they were once tied. It manages the facilities needed to provide villagers with low-cost concentrate feed, milk transport, veterinary services, AI services, and extension and management guidance for their societies. The milk-processing plants are set up to process milk into storable products and can therefore absorb large raw milk supplies. The producer is not then so adversely affected by low prices during periods of high milk production.

A major extension effort routinely gives assistance to farmers. Teams of five or six men visit the villages twice a year to carry out extension work. Each team includes a cattle development officer, a dairy extension officer and a milk supply officer (three positions which are frequently filled by Kaira Union veterinarians), the village "stockman" who is an AI technician and animal first-aid man, and the group-level supervisor assigned to that society. Frequently, techniques such as pregnancy diagnosis of buffalo are demonstrated to arouse the villagers' interest, and their attention is then directed to the particular subject the officials desire to communicate. Indian government family planning officials who recently joined these teams as observers are considering adopting their techniques. Veterinary and AI services (excluding emergency veterinary services) are furnished free to the villager. The veterinary service is organized to make routine calls to each village once a week and to take emergency calls as they occur. There are 42 veterinarians working at the Kaira Union. Other unions are not so well staffed. In some unions the veterinary as well as the AI service is provided by government personnel. The Kaira Union delivers buffalo semen to the villages daily. The semen is packed in ice and delivered to each village by the morning milk collection truck. The village stockmen inseminate the buffaloes that are brought to the society's restraining facilities.

Smallholder livestock development in Kenya

Smallholder livestock development in Kenya provides a contrast to the unified and coherent direction of development efforts in Gujarat. In Kenya, the results of development cannot be attributed to one or several projects, but rather to the efforts of local government and parastatal bodies, bilateral and multilateral assistance agencies and several individuals, to the initiative of small farmers themselves, and to a national priority for smallholder development. Livestock production for two types of smallholder was investigated: the smallholder crop-dairy farmers in the Mount Kenya area, and the Masai group ranches of the Kajiado district. The experiences of the credit institutions and the cooperative movement were emphasized in this survey.

Smallholder dairy farming in the high potential area

An estimated one million families operate smallholdings in the high potential farming areas of Kenya.[1] Many smallholders have registered title deed tenure. Typically these smallholders own from one to five dairy cows, of which many are grade animals and some are zebu or zebu-dairy breed crosses. The size of the farms ranges from less than 0.4 ha to about 3 ha. Farm production is diversified. Pyrethrum, coffee, tea, vegetables, maize and/or fodder are grown.

Dairy production has become a desirable addition to the farming system because it creates an even cash flow, and fits well into the farm labour distribution pattern. Also, the high milk price fixed by the Government was undoubtedly a major cause for the interest in milk production. The meat price for live cattle sold to the Kenya Meat Commission, on the other hand, was fixed at a low level. The combination resulted in premature slaughter of many dairy bull calves because the farmer realized a much higher return from selling his milk than from feeding it to a calf. Milk marketing is carried out by the local societies, many of which are federated into district unions. These societies provide collection centres for the milk as well as distribution points for some of the inputs for production. The unions provide dairy feed on credit against milk sales.

The group ranch scheme

Group ranches with communal ownership of land and individual ownership of cattle have been developed as a solution to the problems faced by the nomadic pastoralists, the Masai. In the early 1960s the Masai were faced with a serious drought and a plague of army worms. Death losses of cattle were high. At the same time, they were beginning to feel the pressures of land scarcity. They were therefore receptive to offers from Ministry of Agriculture officials to design plans for the proper development of their cattle business. This initiative was the beginning of group ranch development.[2] The idea of communal land ownership, with maintenance of individual cattle ownership, was proposed, and after a few years of negotiation the first group ranch, with 30 families, was formed. Nomadic pastoralists became sedentary cattle raisers. In 1971-72 five more group ranches were formed. About 700 families live on these ranches. Loans have been made to the ranches by the Agriculture Finance Corporation (AFC), with group responsibility for repayment.

The problems of who should hold how many cattle and the proportionate use of resources have been worked out to the satisfaction of the Masai. This does not mean that the solution is final, but at present the group ranch members are satisfied. One of the most attractive features of the plan to the Masai is that they now have title to land.

To delve into the sociologic aspects of this approach is beyond the scope of this article.[3] The fact of the matter is that this was the most acceptable alternative solution to the desperate problem faced by the Masai. This concept also appears to be attractive to other Masai groups, because some 50 more ranch groups have asked to be designated for financing under a loan from the International Development Association. The prospective members have been registered and are waiting for financing and development implementation, and their land has been adjudicated. The efforts of a few individuals in designing and implementing this plan are largely responsible for the successful outcome. The early days of planning involved numerous discussions with the Masai. Many plans were formed and revised. A new land adjudication act had to be written as well as new laws governing group ownership of land.

Some of these original planners continue to work with the group ranches in Kenya directly or indirectly. This continuation of management experience has been an important reason for the successful development of the group ranch scheme.

The results highlight the sociological dynamics that can occur in certain groups in response to alterations in their social and physical environment. This does not mean that the resultant change in sociological patterns is not upsetting, but indicates that the upset of the change from a nomadic to a sedentary life is relatively acceptable because of the opportunities offered by the new order.

Experiences of credit institutions with lending to smallholders

The Agriculture Finance Corporation, the Cooperative Bank and commercial banks have extended credit to smallholders. The AFC is a development bank that carries out various activities in association with government to administer development credit programmes, and has more experience than any other organization in Kenya with smallholder credit. The commercial banks' lending policies are conservative. The recently formed Cooperative Bank delivers credit through the cooperative organization, and has lent money mainly for coffee production.

The AFC has been involved in small-

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[1] High potential means an area which has over 850 mm rainfall. In Kenya this area is about 14 percent of the country (10 percent of the crop and livestock smallholders live in this area) and has 56 percent of the domestic livestock units.

[2] More description is offered by M. Simpson, *Alternative strategies for range land development in Kenya*, University of Leeds, March 1973. — H. Jahnke, H. Ruthenberg, H.J. Thimm, *Range development in Kenya. The Kenya Livestock Development Project and its impact on rural development*, Nairobi, December 1972.

[3] For discussion of the sociological features of group ranches, see H.G.B. Hedlund, *The impact of group ranches on a pastoral study*, Institute for Development Studies, University College, Nairobi, Occasional Paper No. 1, April 1967. — R.K. Davis, *Some issues in the evolution, organization and operation of group ranches in Kenya*, Land Tenure Centre, University of Wisconsin. Reprint from *East African Journal of Rural Development*, Vol. 1, 1971.

holder credit schemes since 1955 and has tried various methods of security and loan supervision. In general its experience is that making long-term (two- to five-year) loans without land title security has led to poor repayment. The quality of technical supervision also influenced repayment.

Most long-term smallholder lending has been to the crop-dairy farmers of the high potential area. The lending for grade dairy cattle under conditions of title security and good technical supervision has been relatively successful, and the demand for credit for cow purchase is much higher than expected. This success undoubtedly results in part from the milk price policy, but the demand for smallholder dairy loans was high even before the presidential price decree of 1971.

The commercial banks have been making long-term loans to certain smallholder livestock producers for many years. They usually demand more security than does the AFC. Nowadays, in addition to land title, most commercial banks will extend credit only when the loanee can show an existing, well-established source of income, such as coffee production or outside employment. Commercial banks, because of their high liquidity, would like to increase their lending to smallholders but cannot justify the cost of field supervision which would be required if they relaxed their security policies. They consider smallholder lending good for their public image as well as a way of opening new loan markets.

The Cooperative Bank was started in 1968 because members of all types of cooperatives desired a credit and savings institution within their cooperative movement. The Cooperative Bank does not maintain individual accounts and makes agricultural loans only to unions and societies. Most lending has been for coffee production, and the performance so far has been excellent. The loans for dairy cow purchase by the Cooperative Bank have been negligible. One union has made a few loans with Cooperative Bank funds for dairy cows as an experimental venture. It plans, however, to use returns from coffee production rather than from milk for loan payment. This arrangement reflects the concern that milk might easily be sold outside of cooperative marketing channels, thereby debasing the market monopoly.

The Masai now participate in group ranch activities. These group ranches, with communal ownership of land and individual ownership of cattle, have been developed as a solution to the problems faced by the nomadic pastoralists.

The cooperative movement

Cooperatives were started many years ago by European farmers for the purpose of marketing their cash crops. Later, in the 1960s, many rural cooperative societies were established to fill the economic, political and social needs of rural Kenya.[4]

The aim of the Government was to show that it was taking immediate action for rural Kenyans. This emotionally inspired move was in many instances premature, and resulted in a rapid increase in the number of societies, many of which lacked quality management. In more progressive smallholder areas, these societies are now serving an economic function of input supply and marketing, but have made very little progress in achieving social or political benefits such as health improvement, extension and community cohesiveness. In the recent past, however, internal squabbling, corruption and embezzle-

[4] A worthwhile discussion and review of the general philosophy of rural cooperatives with specific focus on Africa is offered by R.J. Apthorpe. He also discusses the problems of credit administration by cooperatives and concludes that such a practice is questionable. *Rural cooperatives and planned changes in Africa: an analytical overview.* Staff study for United Nations Research Institute for Social Development, Geneva, 1972.

ment have been commonplace. Because the cooperative movement was organized from above, individual society members lacked a sense of involvement and responsibility.[5]

[5] This problem is described in *Cooperatives and rural development in East Africa*, ed. by C.G. Widstrand (The Scandinavian Institute for African Studies, Uppsala), New York, Africana Publishing Corp., 1970. He observes that "Ideally, in the long run it is not until the members themselves feel a sense of involvement and that they have some control over the cooperative (through education, involvement in productive activities, etc.) that efficiency can be guaranteed by pressure from below, by active participation by membership, both in the marketing and producer cooperatives." A discussion of various management problems in cooperatives in East Africa is also offered by Karanja, in a paper, *Rural economic development and management: the case of cooperative management in East Africa*, presented at the 15th Annual Meeting of the African Studies Association, University of Nairobi, November 1972. The particular problems of cooperative management in the resettlement areas of Kenya is described by J. Harbeson, in *Cooperative societies, local politics and development: A Kenya case study*, presented at the 15th Annual Meeting of the African Studies Association, University of Nairobi, November 1972.

Implications of the characteristics of the smallholder's environment

The success of smallholder development efforts depends on many factors and not simply on an institution, a new technology, a leader, or a market system. The achievements which these elements of development strategy attain depend on the quality of land, labour and the physical and social infrastructure of the environment in which they operate, and on the degree to which the society at large supports the idea that the rural poor should have a greater share in the economic growth of the country. Accurate assessment and knowledge of the quality of these characteristics have considerable importance for judging the applicability of the ingredients of successful development to other agricultural areas.

In the environments selected for field investigation in this survey the qualities of these characteristics, i.e., land, labour, infrastructure and societal support, are relatively good. The question: "*Are these smallholders really better off as a result of the development efforts or might they have achieved their position anyway?*" should be asked. Since we will never know the "control" or "no development" achievement, the question seems impossible to answer. However, based on judgement and an understanding of the past position, it seems that the development strategies employed in projects in Kenya and India successfully took advantage of the quality of the environmental characteristics to benefit the smallholder. The bias that the quality of these characteristics introduces in this discussion cannot be removed, and conclusions must be considered with this bias in mind.

The discussion of the quality of environmental characteristics, and the consideration of the specific environments selected for this field investigation, invite the question: "*Does this mean that development efforts aimed at smallholders in environments of lesser quality have not been successful?*" This survey did not reveal examples of successful experiences in assisting smallholders, at least in livestock production, in areas where land quality was poor, labour was totally uneducated or poorly motivated, or basic infrastructure was relatively undeveloped. This does not mean that development efforts cannot be successful in environments of lesser quality than those surveyed, but rather that they have not been successful or have achieved only minimal progress as of today.

The successes have been achieved with smallholders who are potentially most responsive to development because of the quality of their land and their labour. This process of selecting "the most likely to respond" as subjects of development efforts seems logical — the fastest and best pay off from the least cost of development. The question is: "*What are the elements which we should learn to identify and encourage in order to apply our development resources successfully?*"

Major elements of success

People: The smallholders in the cases studied either initiated their own development, or conditions were such that these smallholders were readily responsive to the opportunities provided by the development strategies. The leaders and development workers are dedicated to the development idea and they have been working with the problems for long enough to provide continuous guidance. They have grown with the various schemes which they have designed and have worked tenaciously to overcome the problems that have arisen. These leaders seem to have the ability to motivate and instil confidence in the smallholders and others. The society at large and the governments, regional or national, have been sincerely supportive of rural development in general, and have demonstrated this support by assigning a high priority to the allocation of resources aimed at benefiting the smallholders.

Local level training programmes for smallholders and technical and administrative personnel have been an effective form of subsidization. These programmes, which have trained people in basic animal production techniques, farm management and cooperative administration, as well as in the management of the home, have been the backbone of successful experiences in the development cases studied in Kenya and India.

Cooperative organizations: The cooperatives organized primarily for milk marketing have been a major element in the success of smallholder development. The role they have played has depended greatly on the degree of involvement of the rural member in the society: the degree to which he feels the society is his own and that he has a say in its destiny. In this survey it became evident that

the more societies became vehicles for the delivery of all types of technical inputs and information extension (AI, veterinary services, newsletters), the better they functioned and, in a sense, became vehicles for other types of development, such as the stimulation of village cohesiveness, the awareness of sanitation and health procedures, and the development of community improvement projects.

This survey revealed a contrast in the relative effectiveness of cooperative organizations due to the methods of their formation and operation. In Kenya, where the cooperative movement had been imposed on rural inhabitants without much care being given to the quality of local involvement, many societies have failed to function beneficially for the smallholder member and many have been dissolved, basically because of local internal disagreement and lack of member confidence.

The contrast is seen in the Kaira Union in India, where great care is taken to form the societies with the solid support of the village members, and the union is active to ensure their continuing healthiness. The point is that unless cooperative organizations are formed with the constant involvement and support of the villager, they are headed for serious problems.

Market systems: Milk production was the main smallholder livestock activity investigated in this survey, and a functioning marketing system was clearly an element for the successful development of the smallholder dairy business. The handling of the limited quantities produced by smallholders can be best managed through the cooperative organization.

Price policies: Price stabilization is important. Milk processing can contribute to price stability in areas where there are large seasonal variations in supply: the fact that these variations can be absorbed by producing storable milk products results in a stable, predictable price throughout the year and inspires producer confidence in the market.

Credit policies: The extension of credit to smallholders under proper conditions has been an important element in smallholder dairy and pastoralist beef production. This survey found that experiences with smallholder credit, however, have not been uniformly rewarding. The positive experience of the AFC in Kenya with long-term credit in smallholder development has resulted from far-reaching technical supervision and land title security.

In both India and Kenya, the experiences of short-term lending (two to nine months) for in-kind inputs to dairy production against milk sale collaterals have been commercially acceptable. The smallholder is able to keep up the payments and is thus not tempted to sell his milk outside the lending-market channel, and he knows he must keep his account current before he can buy more on credit through the cooperative.

Group responsibility and market monopoly are frequently considered acceptable as collateral for long-term credit where land title security is difficult to obtain, or where, even if obtained, enforcement after default is hard to exercise. In this survey, the general findings do not support these forms of collateral as being adequate to achieve an acceptable repayment performance for long-term credit.

The indications are that the Masai group ranches may well prove to be an exception to this statement. In the Kaira Union, attempts to use group responsibility as long-term loan colateral have resulted not only in poor repayment but in a weakening of the society-villager relationship. This is linked to the fact that milk can easily be sold outside of cooperative channels, thereby debasing the market monopoly idea.

In general, the experiences in long-term credit for smallholders covered in this survey indicate that acceptable repayment can be expected if title security and well-trained loan supervision operating at the farmer level are available, and that alternatives of market monopoly and group responsibility have not been adequate security under the conditions of administration in Kenya and India. Besides being commercially unsound, poor repayment has resulted in the weakening of the cooperative organization and in damage to an immature credit discipline -- situations which may in themselves be sources of smallholder development failure.

Another point that is implied by this discussion on credit collateral is that favourable land tenure programmes are a prerequisite for successful long-term lending to smallholders.

Summary

The findings of this survey suggest several essential elements for the design of smallholder development strategy. Techniques should be devised to assess the potential responsiveness to development efforts of the smallholder, his local organizations and his government. Subsidies, justified in part by social payoff, may well be required to provide (*a*) a market system that fulfils the needs of the smallholder, and (*b*) training programmes for rural inhabitants and technicians. The formation of local cooperative organizations in which the individual members are involved and feel involved should be encouraged. Existing local groups should be strengthened to better serve their members with assistance in improving production and marketing, and with social benefits.

There are no reasons evident from this survey why the development of the smallholder and the commercial agriculturist cannot proceed simultaneously. Advances made in the commercial agriculture sector have had complementary effects on the smallholder sector. To achieve the objective of income distribution, care must be taken to ensure that institutions and policies established for commercial agriculture do not create disincentives detrimental to the smallholder. For example, a market system that is geared to handle only large quantities and a uniform quality of the raw product would work against the interests of the smallholder.

Recent advances in pasture development in the Peruvian tropics

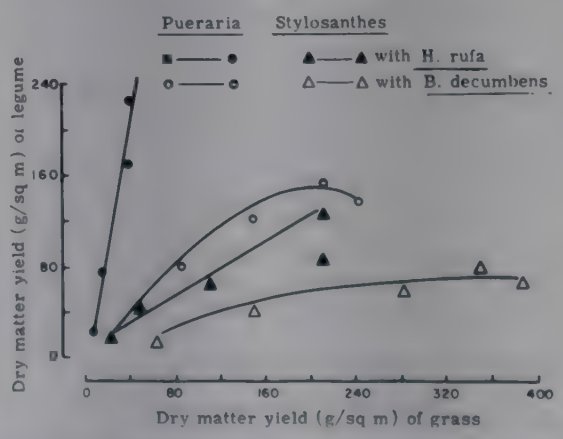
The Peruvian tropics or selvas comprise approximately 30 million ha rain forest, with an annual rainfall varying from 1 500 to over 3 000 mm. The soils are of alluvial origin and are classified as ultisols and oxisols. They are characteristically acidic with a high aluminium content, and are deficient in nitrogen and phosphorus.

The major part of the work reported here was carried out at the Principal Tropical Research Station in Pucallpa of the Veterinary Institute for Tropical and High Altitude Research of the San Marcos University (Santhirasegaram *et al.*, 1972, 1975).

Pucallpa is situated at latitude 8.5°S, longitude 74°W at an altitude of 150 m. The annual rainfall of 1 600 mm is fairly well distributed; the months of June, July and August are relatively dry. The mean maximum temperature is 30.8°C, and the mean minimum 18.7°C. The soil is a red-brown clay loam classified as an ultisol. It is acidic, high in aluminium and low in nitrogen and phosphorus.

Traditionally the forest is cut and burned, and *Hyperrhenia rufa* (yarragua) is sown into the ash. The resultant grass growth is very good as the ash has improved fertility, and the pasture can carry two to three cows per ha. But this high productivity declines by about the fifth year, when the soil improvement caused by the heat of burn and the resultant ash is exhausted. Grass growth deteriorates and other less productive species such as *Paspalum virgatum* (remolina), *Paspalum conjugatum* (toro urco) and *Homeolepis aturensis* dominate. In extreme cases, replacement by *Axonopus compressus* (pasto alfombra) and *Pseudoelephantopus spicatus* (mato pasto) may occur. At these stages the pasture is unable to carry even one cow per 2 ha, calving rates are less than 40 percent and growth rates of calves are reduced to less than 200 g per day.

1. *Regression of dry matter yield of legume with dry matter yield of grass in association (increase in yield is related to length of time of association)*



Selection of legumes

On the assumption that *Hyperrhenia rufa* would be a suitable grass for the environment, research efforts were concentrated on the selection of legumes for inclusion in the grass swards. It was generally believed at the start of these studies that due to the high acidity and aluminium content of the soil, application of lime would be a prerequisite for the development of pasture in the region (Fox, 1969; Motooka, 1970; Estrada, 1971). However, this was not in ac-

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by K. Santhirasegaram

Response of H. rufa *(*above*) and* S. guyanensis *(*below*) to added levels of lime ('000 kg/ha $Ca(OH)_2$) in the ultisol at Pucallpa*

cord with the observation that at Pucallpa and elsewhere there were productive pasture species that had evolved in soils of high acidity and high aluminium content. If these had developed their genetic capacity to tolerate the prevailing soil conditions, there was reason to assume that by using modern techniques of selection and plant breeding it should be possible to find suitable acid- and aluminium-tolerant species.

Experiments were therefore conducted to determine the tolerance of available tropical pasture legumes to aluminium. A comparison of germination rates was made to discover the response of different legumes to the addition of varying levels of aluminium. *Centrosema pubescens* recorded 100 percent germination when up to 15 milliequivalents aluminium per 100 millilitres water were added. Corresponding germination rates for *Desmodium intortum, Pueraria phaseoloides* and *Stylosanthes guyanensis* were 50, 20 and 15 percent respectively.

These results not only showed the remarkable tolerance of *Centrosema pubescens* to high levels of aluminium, but also suggested that improvements in germination rate in the other legumes under these conditions could be achieved by selection. The superior response of *Centrosema pubescens* may be attributed to the natural selection that this species had been subject to under conditions prevailing in Pucallpa, where it occurs. The other legumes were more recent introductions and were grown in areas subject to fire, which reduces the acidity and aluminium content in the soil.

The same pasture species were also grown in pots on Pucallpa soil (6.8 me Al/100 g) with the addition of increasing levels of aluminium. Table 1 shows that the growth of *S. guyanensis* was not seriously affected by the addition of up to 6 me Al, which would result in a level of 12.8 me of exchangeable aluminium in the soil.

A further series of experiments, summarized in Table 2, demonstrated that many tropical legumes and grasses would not require the appli-

cation of lime to correct the acidity and high aluminium content normally encountered in the ultisol at Pucallpa.

On the basis of these results, and after preliminary field experiments in pure stands under grazing conditions, *Stylosanthes guyanensis*, *Centrosema pubescens* and *Pueraria phaseoloides* were selected as suitable legumes for the region. They were planted into existing grass swards or planted with grasses on prepared seed beds, and the associations were subject to different grazing intensities, frequencies and fertilizer regimes. The results showed that these three legumes would persist and yield satisfactorily with nearly all erect growing grasses (e.g., *H. rufa*, *Panicum maximum* and *Paspalum plicatulum*). Persistency was unsatisfactory where the grass companion was a mat-forming type, e.g., species of *Brachiaria* and *Digitaria* (Figure 1).

Table 1 **Effect of aluminium levels (me/100 g soil) on the dry matter yield of three forage species (g/pot)**

	S. guyanensis	*H. rufa*	*D. decumbens*
Al 0	2.33	3.33	3.00
Al 1	2.33	2.50	2.00
Al 2	1.66	3.00	1.66
Al 4	2.00	0.00	2.33
Al 6	2.00	0.00	2.00

Table 2 **Mean dry matter yields (g/pot) in response to levels of added lime (kg $Ca(OH)_2$/ha) in the ultisol at Pucallpa**

	L 0	L 1 000	L 5 000
C. pubescens	11.23	11.67	12.93
P. phaseoloides	8.11	9.22	9.56
S. guyanensis	12.46	12.78	16.69
D. decumbens	48.44	44.32	46.15
H. rufa	25.01	25.15	26.19

Table 3 **Mean phosphate content (% dry matter) of four pasture species in response to added levels of superphosphate (kg/ha) in the ultisol at Pucallpa**

	P 0	P 100	P 500
C. pubescens	0.407	0.465	0.357
S. guyanensis	0.110	0.156	0.336
D. decumbens	0.094	0.124	0.225
H. rufa	0.097	0.098	0.072

Table 4 **Liveweight gains of Nellore type heifers (kg/head) grazing *H. rufa*/*P. phaseoloides* pastures with different levels of phosphate fertilization and supplementation**

Treatment	First six months	Second six months
Control	39.9	20.2
100 kg/ha superphosphate	57.7	21.8
500 kg/ha superphosphate	24.8	35.8
Phosphorus supplement	84.3	76.1
100 kg/ha superphosphate + phosphorus supplement	93.2	83.0

Phosphorus status

Studies in soil mineralogy and phosphate adsorption maxima had demonstrated the high phosphate-fixing capacity of Pucallpa soils (Estrada, 1971). These had led to the view that large quantities of phosphatic fertilizers would need to be applied to satisfy the "phosphate hunger" of the soils, and in early experiments levels as high as 500 to 1 500 kg P/ha were used (Motooka, 1970). Such high levels of phosphorus, equivalent to 5 000 to 15 000 kg simple superphosphate/ha, were beyond the investment capacity of nearly all farmers and enterprises in the region. It also appeared doubtful whether such investments, if made, could be recovered within a reasonable time under the prevailing economic conditions. It was therefore decided to concentrate on those tropical pasture species that had the capacity to extract from the soil the phosphates which are normally unavailable to other species. This involved the study of tropical species with low phosphate contents compared with their temperate counterparts, which grow under conditions of abundant phosphate availability in the soils.

The pot and field experiments that were conducted showed that there were a number of grasses and legumes suitable to the region that would require applications of only 100 kg/ha simple superphosphate for optimum growth. But, while this quantity of phosphate fertilization permitted good growth, the phosphate content of the herbage was insufficient to meet normal animal requirements (Table 3). This raised the question as to whether it would be more economical to apply high rates of phosphate to the soil to raise the phosphate content of the plants, or to apply only the optimum required for their satisfactory growth and provide the additional requirements of the animals in the form of mineral

supplements. It was also noted in this context that higher applications of phosphorus to some plant species had a lowering effect on their phosphate content.

Productivity of grass-legume pastures

With these questions and the basic agronomic data in mind, a number of experiments were undertaken to estimate the carrying capacity of the different pastures and the related animal performance.

The first experiment attempted to determine the optimum stocking rate of a pure stand of *H. rufa* and of a mixed sward of *H. rufa*/*S. guyanensis* fertilized with 100 kg simple superphosphate/ha/annum, using yearling Nellore type bull calves. Considerable increases in carrying capacity and liveweight gain per animal and per hectare were recorded at the end of the year due to the legume and the phosphate fertilization. However, the results were far below expectations.

Another experiment was conducted at about the same time on the growth rate of Nellore type heifers grazing *H. rufa*/*P. phaseoloides* pastures with different levels of phosphate fertilization and mineral supplementation. Table 4 shows that during the first six months of the experiment, the animals on pasture fertilized with 100 kg superphosphate/ha/annum gained more weight than those on control pastures with no phosphate application; but animals on pasture with 500 kg superphosphate gained even less than the control animals. Phosphate supplementation given directly to the animals in mineral licks was far superior.

In the next six months there was no difference in liveweight gain between the control and the 100 kg superphosphate treatments; the 500 kg superphosphate-treated plots were better than the control. Again phosphate-supplemented animals were superior.

These results suggested that the application of 100 kg superphosphate would be sufficient for only six months. This was confirmed by a reexamination of the data from the experiment with *H. rufa*/*S. guyanensis* referred to above. The application of 500 kg superphosphate depressed animal growth, perhaps through depression of the phosphate content of the grass as well as the legume, and this conclusion was supported by the data in Table 4. It also appeared that despite the better growth during the first six months of animals on pastures treated with 100 kg superphosphate, the amount of available phosphorus was not sufficient to meet the total requirements of the animals.

The Nellore type animals used in this experiment did not consume *P. phaseoloides* herbage, which would have been their main source of phosphate. They grazed the grass in preference to the legume and even during the later stages of the experiment, when grass was in short supply, they continued to reject the legume and consequently lost weight. The mineral supplement was a mixture of dicalcium phosphate (60 percent) and

Table 5 **Mean annual liveweight gain (kg/head and kg/ha) of Nellore type bull calves in the four pasture systems at estimated optimum stocking rates**

		kg/head	kg/ha
H. rufa	1.5 animal/ha	82.0	147.6
H. rufa + phosphorus supplement	1.8 animal/ha	130.5	234.9
H. rufa/*S. guyanensis*	3.0 animal/ha	212.5	637.5
H. rufa/*S. guyanensis* + phosphorus supplement	3.0 animal/ha	214.0	642.0

Table 6 **Optimum carrying capacity and costs and returns of fattening bull calves in three pasture systems**

		Grass	Grass + N	Grass-legume
Stocking rate	*animal/ha*	1.5	4.0	3.0
Annual costs	*US dollars*	250.0	896.3	476.4
Annual net return	*US dollars*	49.4	75.1	395.7
Rate of return	*percent*	19.8	8.4	83.0

Table 7 **Some production attributes and economic parameters of beef production in stabilized herds of 100 breedable cows in two pasture systems**

		Grass	Grass-legume
Optimum stocking rate	*animal units/ha*	1.2	2.4
Calving rate	*percent*	50	80
Weaning weight male	*kg*	120	160
Weight of male calves at 2 years of age	*kg*	280	400
Calves 0-1 year	*number*	475	760
Calves 1-2 years	*number*	475	760
Effective pasture	*ha*	1 135	765
Total investment	*US dollars*	399 775	361 438
Total annual costs	*US dollars*	89 313	95 625
Value of production	*US dollars*	93 038	200 739
Net income	*US dollars*	3 731	105 113
Rate of return	*percent*	0.9	29.0

Nellore bull calves of same initial weight and age after eight months in (left) H. rufa *pasture at stocking rate of 1.5 animal/ha and* (right) H. rufa/S. guyanensis *pasture at stocking rate of 3 animals/ha*

common salt (40 percent) with traces of copper and cobalt sulphate.

In the light of these observations the experiment on stocking rates of *H. rufa* and *H. rufa/S. guyanensis* pastures was redesigned. One plot in each replicate was selected at random to introduce another variable of no phosphate supplementation versus phosphate supplementation, but the original stocking rates were retained. All grass-legume pastures received applications of 100 kg/ha simple superphosphate every six months. The mineral phosphate supplements had the same composition as before, but animals not receiving phosphate supplementation were provided with common salt and traces of copper and cobalt sulphate.

The average liveweight gains per animal and per hectare for the various stocking rates, pasture types and phosphate supplementation are shown in Figure 2. The mean liveweight gains per animal over the various stocking rates on the grass, grass + P supplement, grass-legume, and grass-legume + P supplement treatments were 80, 140, 227 and 251 kg respectively. The liveweight gain per animal and per hectare at the estimated optimum stocking rate for the four pasture treatments are presented in Table 5. By including a legume and applying 100 kg/ha superphosphate every six months, the stocking rate and growth rate were doubled, thus giving more than a fourfold increase in productivity per hectare. The use of supplementary phosphate licks with adequately fertilized grass-legume pasture was not advantageous.

This would suggest that tropical animals, like tropical plants, require less phosphate than their temperate counterparts. It was also found that the monthly rate of growth of animals consuming the grass-legume pasture was nearly linear; this indicated that there was little need to conserve feed for the short dry season experienced in this environment.

Economics of beef production

It was concluded from these experiments that a semi-intensive pasture system with 100 kg/ha superphosphate applied every six months is superior to the traditional extensive system based on grass only. Further experiments were also carried out to compare the semi-intensive system with an intensive one where suitable grass pastures were adequately supplemented with phosphate and nitrogen fertilizer. The resulting carrying capacity and growth rates were measured. Based on these data, estimates were made of the costs of fattening male calves in the three pasture systems at optimum stocking rates. Table 6 gives the costs, net income and rate of return.

Using data on calving rates, weaning weights and growth rates, economic parameters of beef production were derived for stabilized herds of 100 breedable cows on the grass and grass-legume pasture systems. A summary of some production factors, costs and returns is presented in Table 7. It needs to be stressed that these estimates are at best tentative, but the relative differences are likely to remain unchanged. The inclusion of a legume and the adoption of phosphate fertilization reduced total investment and changed a nonprofit stalemate situation into a profitable enterprise with an attractive net return of 29 percent.

This net return, however, is based on 100 percent efficiency of operations, which may not obtain under normal farming conditions. In the socioeconomic and technological environment prevailing in the region, an 80 percent efficiency in the management of grass-legume phosphate-supplemented pastures may reasonably be expected. At this level of efficiency the rate of return would be about 18 percent, compared to a negative return under similar conditions for extensive systems on grass only.

Future developments

These results point to the need for the selection of more productive

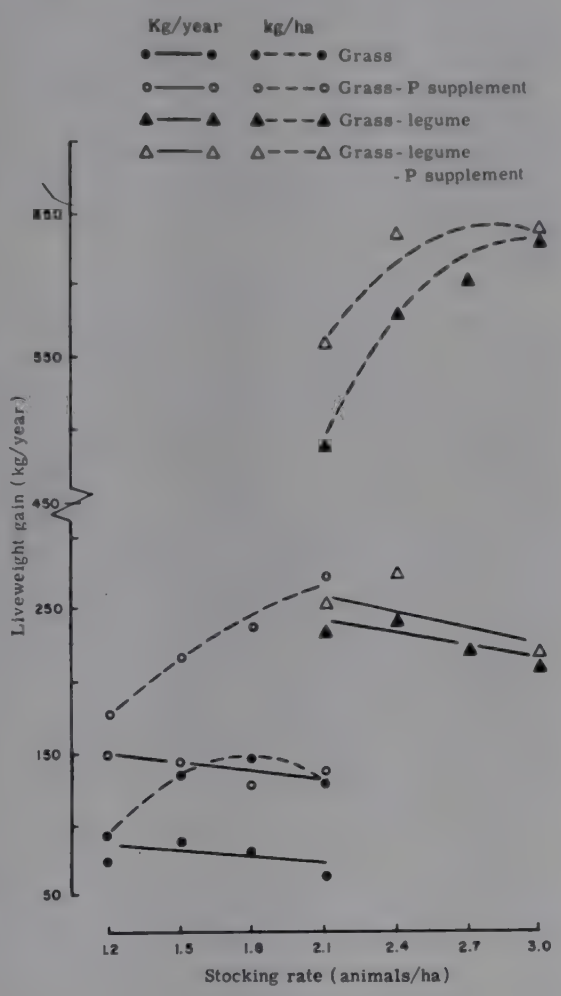
grasses and legumes, giving particular attention to the efficiency of nitrogen fixation by the latter, and for the development of suitable production systems for raising farm income. Too often recommendations on methods of pasture establishment, management and utilization are made without consideration for the economy of the whole farm. Classical examples are the recommendations on grazing systems, in particular on rotational grazing for beef production. The advantages to be gained from these systems are seldom weighed against the capital investment in stock and fences, and the annual costs of fence and water maintenance, and labour. Grazing systems with farm subdivisions that take account of the nature of the pasture, labour requirements for stock handling, and capital and recurrent expenditure, have still to be evolved.

Rotational grazing is often advocated in the belief that pastures require periods of rest for regrowth, and such recommendations are usually based on experiments on cutting heights and frequencies during growth periods. It is, however, not generally recognized that even under continuous grazing or set stocking systems, where the pasture is continuously grazed, the individual plants do get a rest period; animals do not graze all plants in a paddock all the time under a continuous grazing system.

It has been shown in Pucallpa that the frequency of defoliation of the individual plants in a continuously grazed paddock increased with increase in stocking rate. Thus the optimum stocking rate is that at which the individual plants are defoliated at the optimum frequency and intensity. This may be the principal reason for the lack of consistent advantage in the literature of rotational grazing over continuous grazing with beef animals. With dairy animals, however, there are some advantages gained from controlled grazing, but these are due rather to the physiology of lactation than to the system of grazing.

In large farm operations it should be possible to graze the better grass-legume swards during critical periods of the animals' physiology, while at other times they could graze unimproved grass swards, thereby further reducing investment cost. While fattening stock must always graze improved pasture, cows may graze such pasture in the period following conception, and heifers during the growing period with minimal supplementation of phosphorus in the form of licks. Various combinations of pasture types and grazing systems could be developed to maximize productivity and profitability.

2. *Annual liveweight gain of Nellore type bull calves grazing pasture systems at varying stocking rates*



Summary

A pasture improvement programme currently in progress at Pucallpa in the Peruvian tropics has been described. Traditionally the rain forest is burned and *Hyperrhenia rufa* is sown on the ultisols which are acidic, high in aluminium and deficient in nitrogen and phosphorus. Such grass pastures stabilize with the invasion of less productive species at a carrying capacity of less that 0.5 cows per hectare, accompanied by long calving intervals and low growth rates.

Pasture productivity was improved by the inclusion of legumes adapted to the high acidity and to the high aluminium content of the soils. Dry matter yields and protein content increased. Phosphorus deficiency was corrected by the application of 100 kg/ha of simple superphosphate every six months. The resultant grass-legume pasture doubled both stocking rate and growth rate, and gave more than a fourfold increase in livestock gain per hectare compared with the traditional pastures. Liveweight gains averaged 638 kg per hectare per year, and compared favourably with gains from similar pastures in other parts of the tropics.

Preliminary economic estimates, based on 80 percent efficiency in farm management, suggested an 18 percent return on investment from the grass-legume pastures compared with negative returns from the traditional pastures. Further improvements in productivity and profitability are possible through the selection of better grasses and legumes, greater attention to the efficiency of nitrogen fixation by the legumes, and the development of improved grazing and stock management systems within the whole farm economy.

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CURRENT SITUATION AND PROSPECTS FOR MEAT AND ANIMAL FEEDS

MEAT

After an increase of 4 percent in 1974 — the largest since 1961 — it is expected that world meat production figures will show that there was a substantially lower increase in 1975. One of the main factors influencing the current meat situation is the continuing rise in *beef* production. However, production is beginning to level off in a number of major producing areas.

Heavy cow and heifer slaughterings in western Europe and North America indicate producers' intentions to reduce the size of breeding herds. Cattle inventories in both regions were expected to show little further increase at the end of 1975 compared with earlier levels. Beef output and production potential continue at high levels in all the major southern hemisphere countries, eastern Europe and the U.S.S.R. On the other hand, the national herds appear to be too large in relation to feed supplies in these regions, and consequently there is considerable pressure to accelerate slaughterings and herd culling. The result could be a sizable further increase in output, particularly if the reported deterioration of fodder supplies in some of these countries should continue.

Mutton and lamb production in 1975 (unlike beef) was probably smaller in practically all the main producing countries.

Pigmeat and poultry meat supplies were also below earlier 1975 levels in western Europe and North America. By contrast, very sharp increases were reported in the output of these meats in the U.S.S.R., especially as a result of heavy slaughterings since last June.

The profitability of livestock feeding has improved recently because of increases in livestock prices and some declines in feed costs. Cattle feeding is beginning to pick up in North America and also in some western European countries, but there is still considerable uncertainty concerning the extent of this expansion. Pig prices have been rising in relation to feed costs in both areas for some time; however, the latest livestock data still show no expansion in breeding herds so that larger pigmeat supplies are unlikely to come before the second half of 1976. Many livestock producers are apparently expecting greater stability in livestock and feed prices before initiating major production expansion.

No major demand increases were foreseen for the first half of 1976. In the importing countries, domestic beef and veal supplies are expected to be large and stocks are also unusually high. Severe import restrictions are still in effect. Import demand will therefore remain weak for these commodities. Although the European Economic Community and Japan partially relaxed their import measures during the second half of 1975, the outlook for world trade in these commodities remains poor for most of 1976. The U.S.S.R., which imported large quantities of red meat in 1974, apparently continued its imports at a substantial scale in 1975.

The present imbalance between supply and demand for beef is not expected to alter until the second half of 1976, nor will prices recover significantly. World trade in mutton and lamb is unlikely to have increased in 1975. The major meats with relatively good demand prospects in international trade are pigmeat and poultry meat. Import demand for pigmeat will be strengthened by low production in most importing countries, and hence pigmeat prices are likely to continue to improve in the first half of 1976.

OILSEEDS AND OILMEALS

Forecasts of the main oilseed and oil crops to be harvested in 1975/76 continued to indicate substantial increases in most crops over the level of the previous year. Soybeans, especially, and also groundnuts, rapeseed and palm oil, are likely to show large increases while output of cottonseed and sunflowerseed is expected to decrease. Forecasts remained very tentative, as they were made while annual crops in the southern hemisphere were still being planted. As increases in many crops are heavily concentrated in exporting countries, and since some exporters are already holding sizable stocks, total export availabilities — in terms of both oil and protein — are likely to be particularly large.

World supplies of *soybeans* are expected to be at record levels. In the United States, the latest crop forecast (based on conditions at 1 November) indicates output of 41.4 million tons, 23 percent up from the relatively small crop of 1974 and only slightly less than the record crop of 1973; with beginning stocks (of 5.0 million tons) also heavier than 1973, total United States supplies (46.4 million tons) would be at a record level. The Brazilian crop for 1976 is tentatively forecast to reach 11.5 million tons, a further 20 percent rise from the record 9.6 million tons of 1975. Output of *groundnuts* is also expected to show a sharp recovery, mainly due to the forecast of a record crop in India and somewhat larger output in the main African producers. Higher *rapeseed* output is expected, particularly in Canada. In contrast, world *cottonseed* output will decline, with sharply reduced areas planted in the United States and many other countries. *Sunflowerseed* production is expected to fall for the second consecutive year, although the size of the U.S.S.R. crop — the major producer — is still uncertain. The outlook for *fishmeal* production in 1976 is very uncertain, particularly in view of the unforeseen delay in the opening of the Peruvian fishing season in the latter part of 1975, apparently due to a scarcity of suitable fish.

The outlook for world production of oilmeal protein in 1976 (based on the forecasts for oilseeds and fishmeal) is that output from current crops will reach the record level of 33.5 million tons protein equivalent. This would be sharply higher than in 1975 and about 1.5 million tons above the figure suggested by the extrapolation of the long-term trend. In addition, exporters' opening stocks are probably about 2 million tons of protein. Demand in 1975 was depressed, although price ratios between grains and protein feeds were favourable to an increased use of oil-

meals, by the widespread economic recession and unprofitable feeding margin. Even if demand in the traditional consuming countries shows an expected recovery during 1976 (aided by a likely continuation of the favourable grains/oilmeal price ratio), and taking into account the 1.0 to 1.5 million tons of soybeans reportedly purchased by the U.S.S.R., stocks of oilseed protein (mostly in the form of soybeans) are expected to increase considerably during the season. The 11 November U.S. Department of Agriculture supply/demand estimates forecast an increase in United States soybean stocks during the 1975/76 season of about 5.2 million tons, to reach 10.2 million tons by 31 August 1976. United States closing stocks would then be equivalent to nearly 30 percent of expected disappearance during the season.[1]

COARSE GRAINS

Conditions for 1975/76 improved, although the extent of the improvement is less than predicted due to drought in some large producing countries. Production of coarse grains is estimated to have increased by 2.1 percent to 667 million tons, but remains below the record output of 1973. This recovery reflects both an improvement in yields and a slight expansion in area. Consumption, particularly of feed grains, is expected to expand, but not to the levels of two years ago. Due to the large imports of the U.S.S.R. (11.5 million tons, against 2.5 million tons in 1974/75), trade is estimated to increase by 11.3 percent to 67.5 million tons. Export supplies are available to cover this record level of coarse grain importation, and in certain countries, mainly the United States, stocks will be partially rebuilt. Reflecting a less critical supply/demand situation, prices have declined from their record 1974 levels, but remain close to the average prices of 1974/75 and approximately twice those of 1972/73 before scarcity was experienced.

The outlook for 1976 production remains to be determined, but with only a marginal improvement in stocks expected for 1975/76, and continued overdependence on the outcome of this year's harvests, the Intergovernmental Group on Grains, at its 19th session, emphasized the overriding importance of maintaining a high level of output in 1976/77. Uncertainties concerning the levels of demand for feed persist. Also, as long as recessionary conditions and inflationary pressures continue, consumption of livestock products could be curbed. However, an easing in coarse grain supplies, with its consequent effect on prices, may stimulate feed consumption, but the effects will not be fully apparent until early this year. If continued, the increased demand for feed could require a considerable improvement in production.

[1] Based on the mid-point of the ranges given by the U.S. Department of Agriculture.

Post-graduate course in tropical veterinary science

An M.Sc. course of twelve months' duration will be offered from February 1976 by the Department of Tropical Veterinary Science, James Cook University, Townsville, Australia.

Two major subject areas are available, animal health and animal production. Emphasis will be given to applied aspects of pathology, microbiology (including epidemiology) and parasitology, and to ruminant nutrition and reproduction. Aspects of food hygiene may also be studied. From the second term courses are taken on an elective basis according to the interests of the individual student. A research project will also be carried out in an appropriate field.

Contributions to the course are made by members of the Australian Commonwealth Scientific and Industrial Research Organization, and by research and extension staff of the Queensland Department of Primary Industries concerned with animal production. Full advantage is taken of the range of tropical environments in the Townsville region, including semiarid grassland, savanna and improved pastures in high-rainfall and irrigated areas. There will be opportunities for studying new aspects of tropical agronomy and the use of both *Bos indicus* and *Bos taurus* cattle.

Further particulars can be obtained from:

The Registrar, James Cook University of North Queensland, Townsville, 4811, Australia.

VIIIth International Congress of Animal Reproduction and Artificial Insemination

This congress will be held in Krakow, Poland, from 12 to 16 July 1976. The plenary sessions will consist of invited papers dealing with progress in the biology of gametes, the role of the central nervous system in reproduction, prostaglandins and reproduction, animal reproduction, and AI in tropical areas. Contributed papers may be submitted on any aspects of animal reproduction and AI in domestic animals, and will be presented at the sectional sessions on the physiology of reproduction, pathology of reproduction, and artificial insemination. Panel meetings will be organized for informal discussion and for the presentation of research results. No simultaneous interpretation facilities are to be provided and the language of the individual panels will depend on the decision of the panel chairman.

One day of the congress will be devoted to the demonstration of new equipment and apparatus, special treatment of animals, and the presentation of films. Several excursions are being planned to follow the congress, to enable participants to visit scientific institutions, animal experimental farms, national parks and places of historical interest. Detailed information may be obtained from the Congress Office, Institute of Zootechnics, 32-083 Balice/Krakow, Poland.

Working Group for Cooperative Research on Breed Comparison and Crossbreeding

At the present time the rate of displacement of breeds within a country, and of movement from one country to another with the aim of improving productivity, is greater than it has ever been. Usually these changes are based on known superiority in certain characteristics. Too often, however, our knowledge of the relative merits of different breeds (or of strains within a breed) is inadequate, particularly when temperate breeds are being used in tropical climates, or when they are used in a crossbreeding programme to exploit hybrid vigour.

Much more information is needed concerning what improved breeds and strains to use in tropical countries and what role the indigenous breeds can play either as purebreds or as crossbreds. Naturally, national research stations or universities and FAO projects in various countries are collecting such information, or are carrying out trials in order to obtain more comparative performance data. However, with so many different environments, breeds and possible crosses involved, international planning is needed to ensure the optimum utilization of available research resources.

It was with these considerations in mind that the joint FAO/WAAP/WVA/EAAP Consultation on Animal Production and Health Research (Copenhagen, August 1974) listed breed evaluation and crossbreeding among the priority areas in which FAO should initiate action for international cooperative research. Likewise the report of the FAO/UNEP project on conservation of animal genetic resources emphasized that breed replacement often occurs before the substituted breed has been adequately evaluated, especially for its use in crossbreeding,

and recommended more research and more documentation in this field.

FAO therefore invited a small group of consultants to act as a Working Group with the following terms of reference:

(*i*) To define priorities in the evaluation of breeds and crossbreeding programmes within the general field of animal resources

(*ii*) To review work already done or in progress in this field and to recommend specific research programmes which should be instituted

(*iii*) To suggest means by which such programmes of research could be undertaken on a cooperative basis between research institutions in different countries

(*iv*) To propose ways and means of financing such programmes

(*v*) To make proposals on procedures for summarizing, interpreting and distributing information on evaluation of breeds and crosses.

The first meeting of this Group was held in Warsaw, Poland, during 27-29 June 1975. Selected geneticists were invited from Australia, Costa Rica, Czechoslovakia, France, India, Nigeria, the United Kingdom and the United States. ILCA was represented and, of course, the Animal Production and Health Division of FAO. The Group stressed that the concept of conservation, evaluation and utilization of animal genetic resources needs to be seen as a whole and recommended that international machinery be developed for guidance and support to research on breed comparisons and crossbreeding, as well as to conservation and direct practical utilization. In addition to making a number of specific recommendations on FAO's regular programme activities on research in breed evaluation and crossbreeding, the Group strongly endorsed the follow-up activities to the joint FAO/UNEP project proposed by FAO. These involve *inter alia* trypanotolerant cattle, prolific tropical sheep, and the Criollo cattle of Latin America.

I.L.M.

The World Food Conference of 1976 - The role of the professional in feeding mankind

The World Food Conference of 1976 (27 June to 1 July) will be a meeting of professionals for the international exchange of information on the production, processing, distribution and utilization of food, adequate nutrition, and related subjects. It will be a multidisciplinary conference embracing biological, physical and social scientists and scholars in the humanities.

Representatives from most countries of the world are expected to attend. Students from universities in many countries who are preparing for professional careers related to world food production, will also participate. Attendance will probably exceed a thousand people.

This conference is one of the few events in the United States to be

Letter to the editor

INTENSIVE FEEDING SYSTEMS FOR BEEF PRODUCTION IN DEVELOPING COUNTRIES

Sir,

The letter from A.H. Bishop in your issue No. 14 of 1975 raises points which are indeed relevant to developed countries involved in the export trade in beef. But Mr. Auriol's article (issue No. 9, 1974) was related primarily to developing countries, and certainly in Africa experience in this project fully supports Mr. Auriol's thesis.

The fact is that, in Africa at least, beef production systems based solely on range and pasture have normally failed to:

- *produce adequate and reliable supplies of beef for local consumption;*
- *produce sufficient beef to keep existing export abattoirs and export markets reasonably supplied;*
- *realize anything approaching the potential production from existing national herds, because of their chronic state of malnutrition and semistarvation;*
- *prevent substantial numbers of cattle dying of starvation in the droughts which are the norm over much of the continent;*
- *prevent accelerating destruction of the range in the drier, overutilized areas;*
- *make full use of available cattle feeds (largely by-products) currently available;*
- *provide the pastoral people with a stable way of life which will cater for their increasing numbers and satisfy their rising aspirations.*

This general situation is illustrated by the fact that in Kenya over the past 15 years the annual intake of the parastatal abattoir organization has failed to rise and is now declining sharply, and that the average carcass weight of cattle received has fallen by over 15 percent in the same period. At the same time seasonal shortages of beef on local markets are becoming increasingly severe and export opportunities have not been fully exploited, despite major government efforts to increase sustainable range production from areas generally already overgrazed and abused. It is these realities that support the case for intensive systems to be superimposed, not as alternatives to range and pasture-based systems, but to complement them, to stave off, at worst, their collapse and to increase overall cattle productivity rapidly enough to meet today's needs.

Range and pasture-based systems will, of course, remain the basis of beef production in the semiarid developing countries for the foreseeable future; much of their land resource has no alternative use except for other ruminants or for wildlife. Even in the United States in 1972/73 (boom days for feedlots), despite the fact that about 97 percent of steers and heifers slaughtered were finished on rations containing some grain, roughage accounted for about 75 percent of the total feed consumption of all beef cattle. Much of this roughage was, of course, produced on land unsuitable for the direct production of human food. Since 1973/74, as a result of economic pressures, the proportion of grain in the total feed consumption of U.S. beef cattle has certainly fallen from the 25 percent level of the early 1970s. It is not suggested that developing countries should follow at all closely this American pattern. The actual grain and land requirements of a significant beef-finishing sector in Africa are almost negligible in relation to the increases in beef production that can be derived therefrom.

First, Africa in particular is blessed with indigenous zebu cattle which are incredibly hardy under adverse range conditions and will finish (i.e., lay down lean and fat on an existing skeleton) extremely rapidly in feedlots on rations containing as little as 33 percent of concentrate

endorsed by the American Revolution Bicentennial Administration as a project with "national and international significance for the bicentennial." It has also been endorsed by the Iowa American Revolution Bicentennial Commission.

Financial support for the conference is being provided by the state and federal bicentennial agencies, agribusiness organizations, and foundations committed to finding solutions to world food problems.

Sponsored by Iowa State University in Ames, Iowa, one of the oldest and best-known land-grant universities, the World Food Conference will be an important part of the bicentennial observance.

The programme includes plenary sessions and workshops. Simultaneous interpretation will be provided in English, French and Spanish.

The plenary sessions will assess the present situation, examine the constraints, and appraise alternative solutions to world food problems.

In preparation for the workshop activity, four concurrent subplenary sessions will concern themselves with regional and/or national topics relating to: (1) national and international policies affecting food supplies and use; (2) technology and change; (3) conservation of natural and human resources; and (4) impact of the world food situation on people, environment and development.

Immediately following the four subplenary sessions, speakers will join the workshops and participate in the deliberations. The workshops will be conducted in English. Workshop topics include: (1) institutional resources; (2) technology for food production and processing; (3) impact of the changing food situation on people; (4) food production policies; (5) distribution and marketing policies; (6) physical resources for food production; (7) impact of the changing food situation on development; (8) consumer policies; (9) impact of the changing food situation on environment; (10) adoption, selection and use of technology; (11) maintaining and improving plant and animal resources; and (12) human resources.

Further information can be obtained from Dr. Marvin Anderson, Executive Director, The World Food Conference of 1976, 101 E.O. Building, Iowa State University, Ames, Iowa 50011, United States.

International courses in pig and poultry husbandry

The sixth series of international courses in pig and poultry husbandry will be held in the Netherlands from 8 September 1976 to 11 March 1977. They are primarily intended for students from developing countries who perform teaching or advisory functions in pig and poultry husbandry. The courses will be conducted in English and will take students

feed on a dry matter basis. None of this concentrate need be grain fit for human consumption; much of the total ration can be derived from by-products, and the land requirement for the basic forage can be as low as a hectare per one hundred head of cattle finished annually.

Second, the diversion of small quantities of grain or its equivalent and small areas of high potential land to intensive cattle feeding can lead to quite disproportionate increases in edible carcass weight, quality and marketability from the existing national herd. The conversion of manufacturing grade beef into medium to high quality carcass beef can almost double the foreign exchange earnings from a given number of cattle, or can combine increased foreign exchange earnings with increasing supplies for local consumption.

Third, the benefits of an intensive finishing sector can be obtained without first changing the traditional cattle-based way of life of the pastoral people. The development of new outlets for their surplus male animals at a younger age can buy time in which more radical changes in their social system can be brought about. For it is their social system that inhibits the application of knowledge, not the lack of knowledge itself as implied by Mr. Bishop, that leads to range destruction. In fact, given the existing social system, overgrazing is normally a rational individual decision. Improved outlets for surplus cattle will keep present social systems working a little longer without disaster and thus allow new land tenure systems to develop, permitting herds to be more efficiently managed in their environment.

Fourth, Mr. Bishop's final paragraph implies that the feedlot sector will be monopolistic and exploitive. Experience so far in Kenya indicates that this not be so. Competition both between feeders and other buyers of unfinished cattle for consumption or manufacture has so far worked to the distinct advantage of "the indigenous industry" in Kenya, as immature prices have risen much faster than finished carcass beef prices since a feedlot sector was established. A point which has clearly escaped Mr. Bishop is that when capital investment is related to output ($ per ton of beef produced), grazing systems of production are often much more highly capitalized than are the modern feedlots.

Fifth, a significant feedlot sector can be created in a short period and can bring about substantial and almost immediate increases in production. In Kenya a new feedlot sector has developed within three years, mainly in the private sector, capable of adding an extra 3 300 tons of beef per annum to national output and of supplying 50 000 head per annum of finished cattle, or over 50 percent of the present total carcass throughput of the National Meat Commission. This has been achieved at a time when the world beef situation and local marketing policies have sometimes been less than favourable.

In fact, given the near-impossibility of any rapid improvement in range and pasture management practices within present social systems based on communal grazing, the development of an intensive growing-out and finishing sector, based on feedlots and associated grazing, seems to be almost the only way in which fuller use can be made of existing national herds to meet current and future needs. Intensive systems are complementary to both existing and improved pasture and range systems, not competitive alternatives. Yet even with the full development of intensive systems, beef production in the developing countries will remain, as it has remained in the United States, based essentially on grazing and forage production.

Mr. Bishop's case, as recognized by Mr. Auriol, is mainly applicable to countries with underutilized range and pasture resources, such as, until recently, Australia and parts of Latin America. It does not apply generally to developing countries, and certainly not to those in the semiarid regions of Africa.

Yours, etc.,

H.A. Squire,
Production Economist,
Kenya Beef Industry Development Project,
Private Bag,
Nakuru, Kenya

to an advanced undergraduate level. The coverage includes both theoretical studies and practical work.

Details regarding admission requirements, fees, accommodation and the two syllabuses can be obtained from: The Director, International Agricultural Centre, P.O. Box 88, Wageningen, Netherlands; or The Director, Barneveld College, P.O. Box 64, Barneveld, Netherlands.

International Congress on Rabbits

The International Congress on Rabbits, organized by the French Scientific Association for Rabbit Production, will take place at Dijon, France, from 31 March to 2 April 1976.

The principal themes for discussion at the Congress are: selection, nutrition, pathology, physiology, breeding techniques and production quality.

Further information may be obtained from: Congrès International Cunicole, E.N.I.T.A., Dijon, 21800 Quetigny, France.

Postgraduate study in animal breeding

The Department of Genetics and the School of Agriculture of the University of Edinburgh jointly offer the following postgraduate courses in the field of the genetics of animal breeding which are recognized by the Science Research Council for the award of Advanced Course Studentships:
Diploma in animal breeding (9 months: October-June);
M.Sc. in animal breeding (12 months: October-September).

These courses have been running now for a number of years. Edinburgh has a long tradition in teaching and research in animal breeding; in addition to the University departments, the Agricultural Research Council's Unit of Animal Genetics and the Animal Breeding Research Organization are both located on the same campus. Staff from these units participate in the teaching programme, and discuss their research.

The formally taught component for both these courses is the same, and covers a range of subjects, including: Applied Statistics; Quantitative Genetics; Animal Breeding Theory; Growth and Development; Reproductive and Environmental Physiology of Farm Animals; Selected Topics in Livestock Production and Improvement. The courses are aimed at providing students from the United Kingdom or overseas with the basic knowledge and skills to direct animal breeding programmes or to undertake research.

The Diploma terminates with examinations in June, while the M.Sc. includes an additional three-month dissertation project. Facilities may exist for outstanding students to study subsequently for a research degree.

Application forms and further particulars regarding course content can be obtained from either The Institute of Animal Genetics, or The School of Agriculture, The King's Buildings, West Mains Road, Edinburgh 9.

Applicants should hold an honours degree or its equivalent in any biological science, veterinary medicine or agriculture.

new books

The neotropical savannas

OTTO HUBER. Istituto Italo-Latino Americano, Rome, 1974. 866 pages. Price US$20.00 (Multilingual edition)

For the first time a comprehensive bibliography on the savannas of Latin America has been published, which coincides with the increased attention being paid to the improvement of the production potential of these areas for human and animal nutrition. The author, as an ecologist, has selected his 2 136 references with particular attention to his field of study. Yet the bibliography contains valuable references to the whole problem of making the most rational use of the savanna areas, and should therefore be widely consulted by everyone concerned with the subject.

The bibliography is divided into 13 chapters referring mainly to specific areas, e.g., the "area of the Colombo-Venezuelan Llanos" or the "northern Chaco area." Each chapter is then generally subdivided into four sections dealing with phytogeography and plant ecology, edaphology, climatology, and biotic factors, with special attention to the use of fire and grazing. The references are followed by a summary of the contents in the language of the work cited. The introduction, explanatory notes, collection of works of general interest, etc., are presented in Italian, Spanish, Portuguese and English. If the summary of contents could also be given in at least two languages (e.g., English and Spanish) in a future edition, this would be extremely valuable. An index of authors at the end of the book contains the names of all the authors and co-authors cited.

This is a much needed bibliography for a wide range of users. Special praise should be given to the author for the apparent freedom from printer's errors and misspellings in the many languages in which the references are presented.

B.M-H.

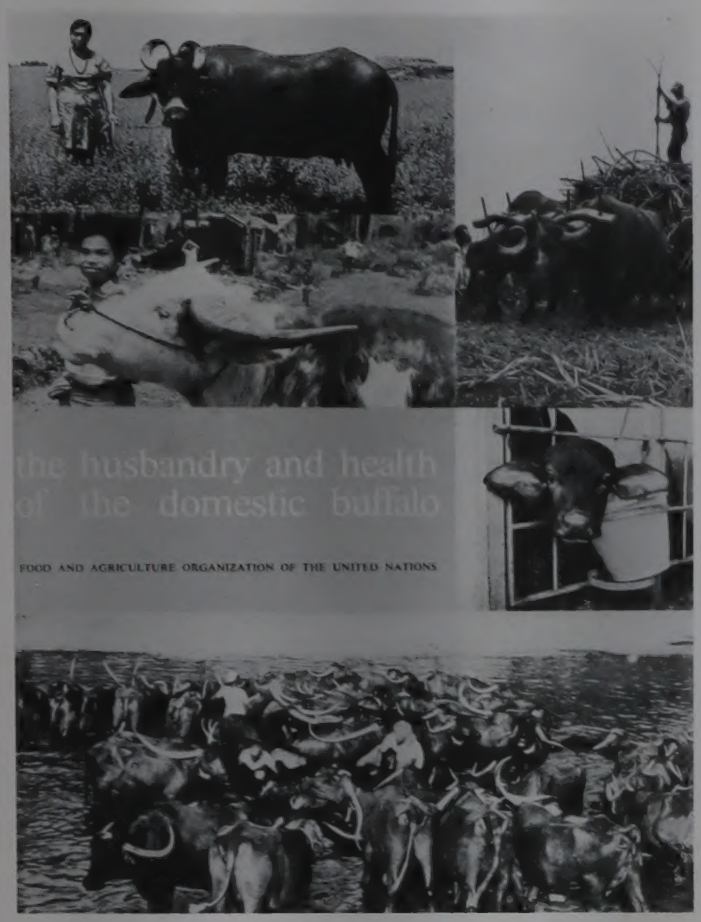
Proceedings of the III World Conference on Animal Production

Edited by R.L. REID. Sydney University Press, 1975. 694 pages. Price: US$66.00. (In English)

The III World Conference on Animal Production was held at the University of Melbourne, Australia, from 22 to 30 May 1973. A summary report of the conference was published in World Animal Review No. 7.

The full proceedings have now been brought together in a single volume by Dr. R.L. Reid and published by Sydney University Press. The volume contains all the papers, together with discussion summaries on the five themes of the conference and the symposium on new techniques in reproduction. The list of delegates as well as author and subject indexes are provided.

P.M.



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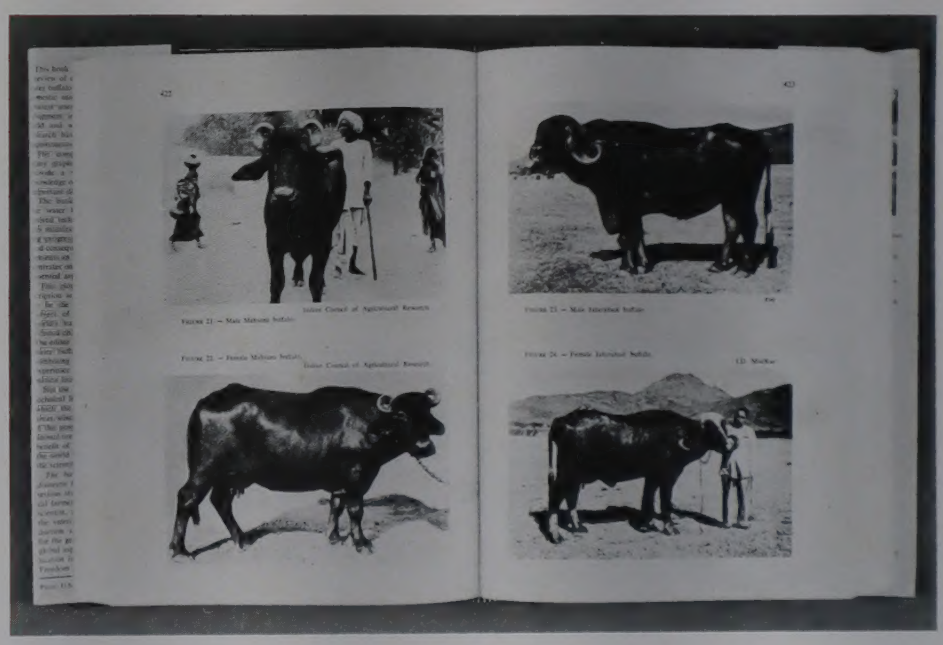

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